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Annual Activities, Work Plans and Budgets

The Soil Management Collaborative Research Support Program

25 September 1993
through
24 September 1994

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Soil Management CRSP Leadership Personnel

Management Entity Office
Roger G. Hanson, Director
Charles B. McCants, Chairman of Planning Committee
Lola Eaddy, Administrative Assistant (Until November 19, 1993)
Barbara Rowe, Secretary
Parker F. Pratt, Special Consultant
Nancy Carroll, Temporary Services

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Hari Eswaran, USDA-SCS
James F. Parr, USDA-ARS
Paul W. Singleton, University of Hawaii/NifTAL
T. Jot Smyth, North Carolina State University
Goro Uehara, University of Hawaii/TropSoils

Communications Program
Timothy P. McBride

External Evaluation Panel
Clarence C. Gray, III
William E. Larson
Benno P. Warkentin

Project Managers
Tejpal Gill
Charles Sloger

I. Executive Summary

A. Introduction

Numerous changes and events initiated during the 1992-93 fiscal year are reflected in the annual activities, work plans, and budgets for fiscal year 1993-94, the final year of the present grant. Much of the Management Entity (ME) Office's energies have been dedicated to planning for a restructured CRSP by completing the Global Planning Workshop, conducting an in-depth evaluation of the component projects and institutions in the CRSP, initiating new members of the Board of Directors, and conducting a number of planning workshops. In addition, $150,000 of funds have been set aside to be used as matching and full funding to respond to short-term technical support for USAID missions. These additional expenses and a 14% mid-year reduction in USAID allocation forced a series of structural adjustments that had to be implemented within the CRSP for FY93 and are reflected in the requests and the suggested allocations presented in these annual activities, work plans, and budgets.

B. Process of Project Evaluation

Each institutional component was instructed to prepare its annual activities, work plans, and budgets for each project in accordance with an accepted outline that would supply information to enable the ME to fulfill the terms and obligations spelled out in the USAID grant. The Board of Directors demanded that each institution's technical committee member be asked to review each of the projects submitted using a standardized evaluation form. Only three of the eight institutional components provided full responses. The ME Director used these inputs, a preliminary draft of the External Evaluation Panel (EEP) report, the services of special consultant Dr. Parker F. Pratt, and input from the USAID Project Officer to summarize these evaluations and, upon estimating a potential funding level, to develop funding suggestions, which were submitted to the Board of Directors as the FY94 funding recommendations. Special weight was given to the EEP evaluation and to the individual project's potential to support the mission and goals of USAID.

C. Process of Allocating Funds

1. Special Set-Aside Funds

The ME Director was instructed by the Board of Directors and USAID to have these funds specifically earmarked to complete the planning and prepare for restructuring and transition of the CRSP:

* An additional $250,000 was to be earmarked for planning to be completed by small working groups.
* $245,495 was to be set aside to be used for program transition as we move from a grant to a cooperative agreement

* $70,000 was to be earmarked for Board meetings and other CRSP operations because of many unknowns.
* A $100,000 contingency reserve was to be earmarked for potential emergencies, opportunities, and services for partner programs.

It is understood that a mid-year assessment of the drawdown from these set-aside funds will be reviewed and any residuals will be reallocated into program activities on a priority basis.

2. Core Funds

The CRSP funding level was reduced by about 14% for the 23 April 1993 through 24 April 1994 period, which includes a major segment of FY94. This reduction included $301,086 from special funds earmarked to help the ME provide the additional administrative strength needed to merge the five programs and conduct the extensive planning needed for the 1994-99 program extension. As a result, some funds had to be pulled away from the program area and allocated to completing the planning process.

The requested level of funding from each of the subprojects and the suggested allocations for FY94 is presented in Table 1. These allocations are still tentative because an additional reduction in funding is expected, and it will reduce funding at the project level for the period from 24 April 1993 through 24 September 1994. This is anticipated, but cannot be implemented in advance.

D. Total Resource Commitments

1. Human Resource Commitments

The total resource commitments (FTEs) for the eight institutional components of the CRSP, summarized from the individual work plans, is presented in Table 2. This is the first year since the 1991 merger that SMSS, TSMM and NifTAL have come forth with estimates so that a total CRSP human resource commitment could be compiled. The major increase over FY93 is in senior U.S. scientists, technicians and administrative support staff supported with core program funds. This summation indicates this CRSP mobilizes 158.84 FTEs globally as scientists, technicians and administrative support staff.

2. Financial Resources

The total financial resources by identified source committed by project and other activities are presented in Table 3. This totals $6,677,050 of which 36% comes from non-CRSP sources. The non-CRSP sources are low because some institutions make no effort to work out host-country institution or collaborating institutional contributions to the success of the specific activity. In addition, external contributions to some specific projects are not reported here

because their institutional administration views the CRSP as a donor agency and not an intra-institutional program.

E. Some Expected FY94 Program Challenges

The Soil Management CRSP, in continued implementation of this present grant and planning the transition to a cooperative agreement, will need to continue to move from the often isolated activity of individual institutions and accept leadership from USAID in soil management as this serves the goals of economic growth and environmental protection. This transition offers new challenges to the CRSP and can also offer opportunities to capitalize on the technology base and make more productive use of the experiences gained over the thirteen years of the CRSP.

The CRSP has been contacted by institutions other than USAID to provide the needed leadership in professional soil management. This CRSP has provided and should continue to provide the needed technical training, leadership and implementation to insure success and the structure for sustainability. The pervasive challenge is less the task than the institutional and directorate support to create, accept, and undertake such opportunities. These and other challenges that can offer opportunities. How they are viewed and accepted will be most critical during this year of transition from a grant to a cooperative-agreement mode of operation.

Table 1. Soil Management CRSP budget requests and proposed allocations
Year 13, 09/25/93 to 09/24/94

Activity		Request	Allocation
Natural Resource Management			
NCSU-01	Comparative analysis of humid tropical production systems	$ 93,700.00	$ 93,700.00
NCSU-02	Soil characterization and interpretation of NRM in the humid tropics	70,800.00	58,500.00
NCSU-06	Processes of soil degradation and rejuvenation under different land use systems	108,700.00	100,000.00
TAMU-01	Processes of soil degradation and rejuvenation under different land use systems	95,229.00	78,000.00
TAMU-04	Land resources characterization and evaluation in the semi-arid tropics	72,722.00	60,200.00
TAMU-05	Integrated management of small watershed and agroforestry systems	173,857.00	126,800.00
CU-01	Light, water and nutrient dynamics in agroforestry systems	82,965.00	82,000.00
CU-04b	Management practices to reduce the impact of surface crusts	92,341.00	46,000.00
CU-05	Land evaluation as a tool for sustained rural development	74,149.00	53,000.00
	Subtotals	$864,463.00	$698,200.00
Sustainable Agriculture			
NCSU-03	Sustainable soil management alternatives to slash and burn	$ 38,800.00	$ 38,800.00
NCSU-04	Agroforestry systems for acid soils of the humid tropics	45,400.00	45,400.00
NCSU-07	Synchrony between soil nutrient availability and plant nutrient uptake	65,600.00	65,000.00
UH-03	Detoxifying aluminum and reducing P fixation in variable-charge soils	26,496.00	26,496.00
UH-04	Maize/legume/rhizobium systems: Interspecific interactions, nitrogen fixation	39,888.00	39,888.00
ADSS-01	Acidity decision support system	32,552.00	32,552.00
PDSS-01	Phosphorus decision support system	128,790.00	116,127.00
UH-05	Tree-crop-soil interactions in an agroforestry system	35,303.00	15,000.00
TAMU-02	Soil and water management and conservation for sustainable agriculture	121,121.00	100,200.00
TAMU-03	Soil fertility management for sustainable agriculture	59,255.00	59,255.00
CU-02	Nutrient flow in relation to plant utilization of N and P	75,100.00	40,000.00
CU-03	Utilizing green manures in cropping systems	78,576.00	35,000.00
CU-04a	Soil chemical properties on struct. stability of soil aggregates in the tropics	38,515.00	35,000.00
	Subtotals	$785,396.00	$648,718.00

Activity		Request	Allocation
Outreach			
NCSU-05	Technical support for research network in the humid tropics	$ 66,700.00	$ 66,700.00
TAMU-10	Outreach activities in the semi-arid tropics	47,817.00	47,817.00
UHTX-02	Technical support and backstopping	121,680.00	50,000.00[1]
TSMM	Economics--USDA/ERS	399,000.00	250,000.00[1]
TSMM	USDA/ARS	248,000.00	-0-
SMSS	Soil Management Support Services--a program of the Soil Management CRSP	562,100.00	400,000.00
COM-01	Soil Management CRSP communications support program	159,100.00	150,000.00
	Subtotals	$1,604,397.00	$964,517.00
Other			
NifTAL	University of Hawaii	$900,000.00[2]	$938,000.00
Planning Costs			
BOD/PI Meetings, Consulting fees and Related Activities		$200,000.00	$200,000.00
Planning Contingency		50,000.00	50,000.00
	Subtotals	$250,000.00	$250,000.00
ME Office/Operations			
ME Office		$370,000.00	$370,000.00
CRSP Operations		70,000.00	70,000.00
Contingency/Reserves		100,000.00	100,000.00
	Subtotals	$540,000.00	$540,000.00
Transition Funds			
Special Transition Activities and Mission Response		$ -0-	$245,495.00
	Possible Budget Total	$4,944,256.00	$4,284,930.00

[1]Escrowed
[2]Estimated

Table 2. Human Resource Commitments

Institution Component	Scientists		Technician	Administration	Other	Total
	Senior	Junior				
	FTE					
United States	19.29	33.69	12.25	13.86	5.35	84.44
Host	10.7	16.8	13.75	6.95	13.1	61.3
Other	2.75	0.75	4	0.6	5	13.1
Total	32.74	51.24	30	21.41	23.45	158.84

Table 3. Total estimated financial resources by identified source committed to the Soil Management CRSP for 1993-1994

Project Number	CRSP	External	Matching	Host	Total
CU-01	$ 82,000.00	$ 0.00	$ 31,391.00	$ 0.00	$ 113,391.00
CU-02	40,000.00	0.00	12,936.00	0.00	52,936.00
CU-03	35,000.00	0.00	25,741.00	0.00	60,741.00
CU-04a	35,000.00	0.00	13,134.00	0.00	48,134.00
CU-04b	46,000.00	0.00	25,856.00	0.00	71,856.00
CU-05	53,000.00	8,000.00	26,223.00	0.00	87,223.00
UH-03	26,496.00	0.00	4,600.00	0.00	31,096.00
UH-04	39,888.00	30,000.00	14,500.00	11,000.00	95,388.00
UH-05	15,000.00	0.00	7,500.00	0.00	22,500.00
UHTX-02	50,000.00	34,200.00	50,600.00	0.00	134,800.00
PDSS-01	116,127.00	77,200.00	28,990.00	11,100.00	233,417.00
ADSS-01	32,552.00	7,600.00	4,850.00	6,100.00	51,102.00
NCSU-01	93,700.00	0.00	23,400.00	53,100.00	170,200.00
NCSU-02	58,500.00	19,000.00	18,700.00	0.00	96,200.00
NCSU-03	38,800.00	0.00	9,700.00	0.00	48,500.00
NCSU-04	45,400.00	0.00	11,400.00	0.00	56,800.00
NCSU-05	66,700.00	22,500.00	16,700.00	66,000.00	171,900.00
NCSU-06	100,000.00	0.00	27,200.00	17,400.00	144,600.00
NCSU-07	65,000.00	12,200.00	16,400.00	20,100.00	113,700.00
TAMU-01	78,000.00	3,000.00	23,811.00	0.00	104,811.00
TAMU-02	100,200.00	0.00	30,287.00	3,000.00	133,487.00
TAMU-03	59,255.00	21,738.00	14,816.00	11,250.00	107,059.00
TAMU-04	60,200.00	23,900.00	18,182.00	0.00	102,282.00
TAMU-05	126,800.00	98,616.00	43,468.00	0.00	268,884.00
TAMU-10	47,817.00	0.00	11,956.00	0.00	59,773.00
COM-01	150,000.00	NA	NA	NA	150,000.00
TSMM-01 (ERS)	250,000.00	10,000.00	167,000.00	20,000.00	447,000.00
TSMM-02 (ARS)	0.00	0.00	0.00	0.00	0.00
SMSS-01	400,000.00	165,000.00	245,000.00	225,000.00	1,035,000.00
NIFTAL	938,000.00	256,460.00	234,500.00	0.00	1,428,960.00
PLANNING COSTS	250,000.00	NA	NA	NA	250,000.00
ME OPERATIONS	540,000.00	NA	NA	NA	540,000.00
TRANSITION FUNDS	245,495.00	NA	NA	NA	245,495.00
TOTAL	$ 4,284,930.00	$ 789,414.00	$ 1,158,841.00	$ 444,050.00	$ 6,677,235.00

NA = not applicable

Global Thrust 1.
Natural Resource Management

SOIL MANAGEMENT CRSP
ANNUAL ACTIVITY WORK PLAN AND BUDGET REQUEST

Fiscal Year: 1993-1994

Project Number: NCSU 1

Title: Comparative Agronomic, Ecological, and Socio-economic Analysis of Humid Tropical Production Systems

Global Thrust: Natural Resource Management

Constraints Addressed: Increasing population pressure in the humid tropics has created a large demand for increased food production on marginal lands. The farmers in such areas do not have access to markets, credit and fertilizers necessary for high-input continuous agriculture. The result is continued and accelerated forest clearing and mismanagement of previously cleared lands. These practices result in local, regional, and global environmental problems. Land management options that allow for continued production of the same piece of land for resource-poor farmers are being developed. Little is still known about the environmental impact of such systems or their economic viability. An experiment that compares agronomic, ecological, and economic aspects of food production systems in the tropics will aid in making appropriate recommendations according to the socioeconomic status of farmers.

Principal Investigators and Institutions:

A.G. Wollum - NCSU

Collaborators and Institutions:

J. Day - USDA Economic Research Service, economic interpretation of Yurimaguas experiment
G. Carlson - NCSU, economic analysis of Yurimaguas experiment
L. Arévalo - INIAA, Yurimaguas, agroforestry components of the project
J. Alegre - ICRAF, Peru, on-site supervision of experiment at Yurimaguas
C. Palm - TSBF, Nairobi; nutrient cycling components of Yurimaguas experiment
A. Salazar - NCSU, graduate student for work in Bolivia
R. Delgadillo - IBTA/Chapare, technical support for cropping system components of research in Bolivia
R. Mejia - IBTA/Chapare, technical support for soil components of research in Bolivia

Objectives:

1. Systematically compare the processes and characteristics of promising management systems for the humid tropics in order to understand how and why these options differ.
2. Be able to recommend, based on this understanding, the use of specific production systems in specific biological and socio-economic environments.

Progress Report: The seventh year of production data were collected for the replicated field experiment in Yurimaguas, Peru which compares five management systems: 1) mechanized continuous cropping, 2) low input cropping, 3) peach palm plantation, 4) multistrata system, and 5) shifting cultivation. Economic data on all field operations, inputs, and outputs for each treatment and crop were compiled into a database for subsequent economic analysis. Preliminary analysis for economic conditions at Yurimaguas show a net deficit for mechanized continuous cropping, and a net profit ranging from US$ 733 to 28776 among the other treatments.

Two trips were made to the Chapare, Bolivia. The first trip was conducted to evaluate research facilities and assess the potential for collaborative research with IBTA/Chapare' personnel at the La Jota Research Station. After collaborative plans were developed, the second trip was to select the appropriate site for the proposed alley cropping experiment. A site adjacent to the Research Station was selected and soil samples were collected to characterize soil chemical and physical properties. Samples were returned to NCSU and are being analyzed. A work plan was developed to address the issue of tree-crop competition effects and P dynamics in agroforestry systems.

Supplies and equipment are being purchased for shipment to Bolivia. A prototype minirhizotron has been constructed and is being tested in Raleigh for its suitability to study root phenology and density of the tree hedgerow roots.

Work Planned for Next Year: Routine measurements will continue in comparative dynamics experiment at Yurimaguas. These include inputs, labor requirements, crop yields, litterfall, and tree diameter, height and yield. Each year soil chemical and physical properties are measured at depths of 0-15, 15-30, 30-50, and 50-100 cm. Soil chemical properties include pH, total N, organic C, exchangeable acidity and bases, and extractable micronutrients. Soil physical properties include bulk density, soil water characteristics, mechanical resistance, sorptivity, and saturated hydraulic conductivity. Economic data, yield, and soil chemical data will be sent to Raleigh for addition to the existing 7-year data base.

There are few changes in the management options relative to the previous year. Shifting cultivation continues under a secondary fallow. The mechanized continuous cultivation treatment continues with a rotation of corn-soybean or peanut-green manure (*Mucuna conchinchinensis*). The low input treatment will return to a kudzu(*Pueraria phaseoloides*) fallow after a rice-cowpea rotation last year. There are no changes to the peach palm plantation and coffee was added to the multistrata system after reducing the stand of *Inga edulis* trees last year.

An experiment will be initiated in Chapare, Bolivia to test the following hypotheses:

1. Tree-crop competition is composed of both above and below ground sources, where above ground competition is mainly for light and below ground competition is for water and nutrients.
2. Synchronization of shoot pruning at the appropriate stage of crop development will reduce above ground competition by increasing the amount of light available to the crop.

3. Shoot pruning will promote root mortality and decay which contributes to an increased crop yield by reducing below ground competition.
4. The appropriate timing of tree root pruning will increase, with mulch application and root mortality and decay, the amount of nutrients available for the agronomic crop.
5. The amount of nutrients available for crops could also be increased by the reallocation of nutrients in the soil profile caused by tree nutrient uptake and transport to the shoot and mulch application.

A 2 x 2 x 4 factorial experiment with treatments arranged in a split-split plot design, utilizing three replicates will be established. The factors will include: two species (*Inga edulis* and *Cassia reticulata*); 2 pruning regimes (trees pruned once at one months after crop planting and trees pruned twice, once two weeks prior to crop planting and the second pruning close to anthesis); and four treatments representing competition components (+trees, +mulch, +roots; +trees, -mulch, +roots; +trees, +mulch, -roots; and -trees, +mulch, -roots). In addition there will be on absolute control (-trees, -mulch, -roots). The agronomic crops will be grown as a rotation of rice, rice, and cowpea during a cycle of two years. Grain yield and stover production by agronomic crop row position in relation to the tree hedgerow will be measured for each crop.

Prior to establishment of plots, soils will be sampled before burning and after burning the forest vegetation, and at crop anthesis for every crop planted for a two year rotation. Plots will be sampled at three positions from the hedgerow, one near, another far (an area free of tree competition), and the other intermediate between the two extremes and at depths of 0.1, 0.3, and 0.5 m. Samples will be analyzed for N, P, K, Ca, and Mg. The micronutrients will be sampled before and after burning and at the end of the first and second years.

Additionally tree dry matter production (prunings, with branches and leaves separated) will be determined. Nutrient content will be determined on component parts for N, P, K, Ca, and Mg.

Root phenology and density will be evaluated 1 m and 2.5 m from the tree hedgerows and at 0.1, 0.3, and 0.5 m depths using specially constructed minirhizotrons. Root images will be conserved using photographic procedures.

Tree seedlings will be planted for the field plots in September 1993 at the La Jota Experiment Station. The rice-rice-cowpea rotation component will be started shortly thereafter and continuing until August 1995.

The field portion of this study will be conducted by Angel Salazar in collaboration with personnel from La Jota Research Station, near the town of Villa Tunari, Bolivia.

Calendar of Events for A. Salazar at La Jota

EVENT	DATE
Land clearing, burning, soil sampling	September 1993
Tree establishment, plot layout, soil sampling	September 1993
Planting rice	September 1993
Measurements, pruning, plant & soil sampling	Sep.-Dec. 1993
Harvest	December 1993
Planting rice	January 1993
Measurements, pruning, plant & soil sampling	Jan.-May 1993
Harvest	May 1993
Plant cowpea	May 1993
Measurements, pruning, plant & soil sampling	May-Aug. 1993
Harvest	August 1993

Research Sites:

INIAA's Experiment Station at Yurimaguas, Peru and IBTA/Chapare's La Jota Experiment Station near Villa Tunari, Bolivia.

Budget:

Total Funding Source, US $1000's

OBJECT	CRSP	EXTERNAL	MATCHING	HOST	TOTAL
Salaries	26.6	0.0	15.0	27.0	68.6
Fringe Benefits	1.8	0.0	3.6	0.0	5.4
Tuition Remission	5.5	0.0	0.0	0.0	5.5
Allowances	8.4	0.0	0.0	0.0	8.4
Consulting	0.0	0.0	0.0	0.0	0.0
Travel, US	1.0	0.0	0.0	0.0	1.0
Travel, Int.	7.0	0.0	0.0	0.0	7.0
Supplies	10.2	0.0	0.0	16.3	26.5
Equipment	2.0	0.0	0.0	1.3	3.3
Communication	3.6	0.0	0.0	1.4	5.0
Shipping/Freight	2.4	0.0	0.0	0.0	2.4
Publication	0.0	0.0	0.0	0.0	0.0
Other Direct Costs	6.4	0.0	0.0	2.1	8.5
Indirect Costs	18.9	0.0	4.8	5.0	23.9
Total	93.7	0.0	23.4	53.1	170.2

Special Budget Requirements:

Of the CRSP funds, $5,000 are targeted to support a post-doc for economic analyses of 7 years of data for the comparative dynamics experiment in Yurimaguas under the direction of John Day and Gerry Carlson. Total cost of this activity with shared with USDA/ERS. An additional $10,600 of the CRSP funds are designated for partial support of field and laboratory supplies, and laborer wages incurred at Yurimaguas to monitor and maintain the comparative dynamics experiment. All other CRSP funds are in support of project activities with IBTA/Chapare, Bolivia.

An IBTA/Chapare vehicle and its maintenance costs will be shared with collaborators in project NCSU 7. In exchange for the vehicle contribution, both NCSU projects will upgrade the IBTA-San Benito laboratory with equipment to perform routine soil and plant analyses for the IBTA/Chapare program. Equipment includes soil stirrers, diluter/dispensers, and a colorimeter.

In the host funding category, IBTA/Chapare has budgeted US $20,100 in support of this project during the coming year. This includes funds for field laborers, office equipment, and field and laboratory supplies. All remaining host funds are estimates of ICRAF and TSBF contributions to INIAA in support of activities in the comparative dynamics experiment.

Human Resource Commitments:

Full Time Equivalents (FTE)

INSTITUTION	SCIENTISTS SENIOR	SCIENTISTS JUNIOR	TECHNICIAN	ADM. SUPPORT	OTHER	TOTAL
US	0.30	1.00	0.14	0.16	0.0	1.60
Host	0.25	4.00	1.50	2.50	5.00	13.25
Other	0.25	0.0	1.00	0.50	5.00	6.75
Total	0.80	5.00	2.64	3.16	10.00	21.60

Narrative explanation of human resources:

IBTA/Chapare has designated Raul Mejia and Roberto Delgadillo as research counterparts for the project activities at La Jota. Both individuals have experience in the agronomic management of short-term crops adapted to tropical conditions. Additionally, Raul will assist with the soils part of the study and Roberto will lend additional expertise to the alley cropping aspects.

Julio Alegre will provide on-site supervision and coordination for continuation of the experiment in Yurimaguas, in collaboration with ICRAF and TSBF. Luiz Arevalo will be responsible for oversight of the daily field activities. Economic analyses will be conducted at NCSU under the advise and guidance of John Day and Gerry Carlson.

Date Initiated: October 1, 1985

Expected Completion: October 1, 1997

Signatures:

6/11/93 — Principal Investigator — Date

6-10-93 — Program Coordinator — Date

Principal Collaborator — Date

Institutional Administrator — Date

DESCRIPCION DEL COMPONENTE

GRAMA: AGROFORESTERIA

CODIGO Y NOMBRE DEL SUBPROYECTO: SISTEMA AGROFORESTAL (CONV. NORTH CAROLI

CODIGO Y NOMBRE DEL COMPONENTE: 22-122-11

Incremento de la produccion de los cultivos en sistemasagroforestales en areas del tropico humedo Boliviano.

UNIDAD EJECUTORA: Proyecto IBTA/CHAPARE

UBICACION DEL COMPONENTE
ESTACION EXPERIMENTAL LA JOTA

DESCRIPCION DEL COMPONENTE:

1 JUSTIFICACION

El incremento de la produccion de los cultivos en areas del bosque humedo de Bolivia, utilizando cultivos agroforestales, brindaria una alternativa viable para el reemplazo del cultivo de coca por un sistema de cultivo de productividad sostenida orientado principalmente a la produccion de arroz, frijol o caupi.

2 OBJETIVOS:

Incrementar la produccion de cultivos de ciclo corto en sistemas agroforestales, mediante la reduccion de competencia por luz, agua y nutrientes entre los arboles y los cultivos.

3 METAS CONTEMPLADAS:

METAS GLOBALES

- *Generar un alternativa de produccion de cultivos de ciclo corto para el uso de agricultores de las areas del tropico humedo de Bolivia.*

METAS DE LA GESTION 1993:

- *Implantacion del experimento en una superficie de 1 ha.*
- *Poda de arboles antes y despues de sembrar los cultivos.*
- *Toma de muestras de raices para determinar el efecto de las podas.*
- *Estudio de la evolucion del fosforo disponible en el suelo.*

BEST AVAILABLE DOCUMENT

AÑO INICIO: 1993 AÑO CONCLUSION: 1995

6. CRONOGRAMA DE ACTIVIDADES

ACTIVIDADES	E	F	M	A	M	J	J	A	S	O	N	D
PREPARACION DEL TERRENO												
DEMARCACION Y HOYADO												
TRANSPLANTE ESPECIES ARBOREAS												
COMBATE DE MALEZAS												
CONTROL FITOSANITARIO												
PODA DE ESPECIES ARBOREAS												
MUESTREO BIOMASA FOLIAR												
MUESTREO BIOMASA RAICES												
MUESTREO DE SUELOS												
DETERMINACION FENOLOGIA RAICES												
DETERMINACION CANT. P. DISPONIBLE												
SIEMBRA DE ARROZ												

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7. BENEFICIARIOS:

51-13

. PRESUPUESTO ANALITICO DEL COMPONENTE:

AFCO	DESCRIPCION	DETALLE	MONTO($US)
.20	MANO DE OBRA		5000.00
213	SERVICIOS TELEFONICOS		400.00
233	ALQUILER DE TIERRAS Y TERRENOS		200.00
250	SERVICIOS PROFES. Y COMERCIAL.		400.00
311	ALIMENTOS Y BEBIDAS P/PERSONAS		200.00
314	PRODUCTOS AGROFORESTALES		700.00
315	MADERA Y PRODUCTOS DE MADERA		300.00
341	PAPEL DE ESCRITORIO		300.00
344	LIBROS Y REVISTAS		600.00
361	SUBSTANCIAS QUIMICAS		3300.00
362	COMBUSTIBLES Y LUBRICANTES		1800.00
363	ABONOS Y FERTILIZANTES		600.00
364	INSECT. FUMIGANTES Y OTROS		300.00
374	CEMENTO, CAL Y YESO		400.00
377	PRODUC. DE MAT. PLASTICO		2400.00
381	PRODUC. SIDERURGICOS FERRICOS		400.00
386	HERRAMIENTAS MENORES		200.00
395	UTILES DE ESCRITORIO		200.00
397	UTILES Y MATERIALES ELECTR.		400.00
398	OTROS REPUESTOS Y ACCESORIOS		400.00
399	OTROS MATERIALES Y SUMINISTROS		300.00
431	EQUIPO DE OFICINA Y MUEBLES		800.00
432	MAQUINARIA Y EQUIPO DE PROD.		500.00
	TOTAL		20100.00

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8.1 PRESUPUESTO DEL COMPONENTE POR TRIMESTRE, AÑO 1993 (EN $US)

SAFCO	DESCRIPCION	I	II	III	IV	TOTAL
120	MANO DE OBRA	0.00	2000.00	1500.00	1500.00	5000.00
213	SERV. TELEFONICO	0.00	100.00	150.00	150.00	400.00
233	ALQUILER DE TIERRAS	0.00	200.00	0.00	0.00	200.00
250	SERVICIOS PROFESION.	0.00	100.00	150.00	150.00	400.00
311	ALIMENTOS Y BEBIDAS	0.00	50.00	75.00	75.00	200.00
314	PRODUCTOS AGROFOREST.	0.00	400.00	150.00	150.00	700.00
315	MADERA Y PRODUCT.	0.00	150.00	75.00	75.00	300.00
341	PAPEL DE ESCRITORIO	0.00	100.00	100.00	100.00	300.00
344	LIBROS Y REVISTAS	0.00	100.00	250.00	250.00	600.00
361	SUBST. QUIMICAS	0.00	800.00	1250.00	1250.00	3300.00
362	COMBUST. Y LUBRIC.	0.00	400.00	700.00	700.00	1800.00
363	ABONOS Y FERTILIZ.	0.00	200.00	200.00	200.00	600.00
364	INSECT. FUMIG. Y OTROS	0.00	100.00	100.00	100.00	300.00
374	CEMENTO, CAL Y YESO	0.00	150.00	125.00	125.00	400.00
377	PRODUCT. MAT. PLASTICO	0.00	600.00	900.00	900.00	2400.00
381	PRODUCT. SIDERURG. FERRICOS	0.00	100.00	150.00	150.00	400.00
386	HERRAMIENTAS MENORES	0.00	50.00	75.00	75.00	200.00
395	UTILES DE ESCRITORIO	0.00	100.00	50.00	50.00	200.00
397	UTILES Y MAT. ELECTRICOS	0.00	150.00	125.00	125.00	400.00
398	OTROS REPUESTOS Y ACCES.	0.00	100.00	150.00	150.00	400.00
399	OTROS MAT. Y SUMINISTR.	0.00	100.00	100.00	100.00	300.00
431	EQUIPO DE OFICINA Y MUEBLES	0.00	400.00	200.00	200.00	800.00
432	MAQUINARIA Y EQUIPO DE PROD.	0.00	200.00	150.00	150.00	500.00
	TOTAL	0.00	6650.00	6725.00	6725.00	20100.00

BEST AVAILABLE DOCUMENT

ELABORADO POR: R. DELGADILLO - A. SALAZAR
RESPONSABLE(S): A. SALAZAR - R. DELGADILLO

SOIL MANAGEMENT CRSP
ANNUAL ACTIVITY WORK PLAN AND BUDGET REQUEST

Fiscal Year: 1993-1994

Project Number: NCSU 6

Title: Processes of Soil Degradation and Rejuvenation Under Different Land Use Systems

Global Thrust: Natural Resource Management

Constraints Addressed: Inefficient Use of Water Resources and High Erosion Rates

Principal Investigators and Institutions:
D. Keith Cassel - NCSU

Collaborators and Institutions:
Dennis Garrity, previously at IRRI, but now at ICRAF, co-leader on research on hedgerows to reduce soil erosion and increase water use

Ken Cassman, IRRI, working with me to relocate the field research site to a location in the Philippines with better infrastructure and support

Fahmuddin Agus, employee of Center for Soils Research, Bogor, Indonesia, currently a student finishing his Ph.D. dissertation on research conducted in Claveria, Mindanao, Philippines

Bir Thapa, a new Ph. D. graduate student at NCSU who began some preliminary dissertation research at Claveria, Mindanao, Indonesia

Objectives:
1. To evaluate several plant species on hedge row terrace formation on acid, infertile, sloping lands,
2. To evaluate temporal and spatial changes in the hydrology (infiltration, redistribution, runoff, and soil loss) of the soil under the various hedge row terrace systems,
3. To evaluate temporal and spatial changes in leaching under hedge row terrace systems, and
4. To quantify temporal and spatial changes in soil physical properties as hedge row terraces develop.

Progress Report: The field work conducted by Fahmuddin Agus directed toward all 4 objectives was completed in late 1992. Fahmuddin returned to the NCSU campus and is currently summarizing data and writing his dissertation and several research papers. He presented some of his results at a Crop Science meeting in the Philippines.

Specifically, the effects of four types of vegetation, planted on the contour in 'hedge rows', on rice and corn production, the soil water balance, and soil loss were evaluated at Claveria, Mindanao, Philippines. Hedge row vegetation was: *Gliricidia sepium* (G); *G. sepium* and *Paspalum notatum* (GP); *G. sepium* and *Pensisetum purpureum* (Napier grass) (GN); and Napier grass (N). Crop yields the first two years after hedge row establishment were less for all hedge row treatments compared to the control treatment without hedge rows. During the third and fourth years crop yields for the G and GP treatments were greater than the control. Crop yield varied spatially with distance from the hedge row, with yield being lowest adjacent to the hedge row.

A bromide ion tracer was applied to the soil surface of some of the plots and monitored temporally and spatially to assess the change in soil water regime caused by installation of the hedge rows and the resulting potential loss of mobile nutrients. The site occurs on a 20 to 30% slope and the climate has distinct dry and wet seasons. Soil water content in the topsoil at various locations in the treatments was measured periodically using time domain reflectometry. Surface water runoff and soil loss, measured in runoff plots, was greatly reduced by the hedge rows. Lateral movement of bromide in the soil occurred for all treatments.

Bir Thapa began some preliminary research leading to his Ph.D. The work involves ridge tillage as a mechanism to help control soil erosion and optimize water storage in soils with 20 to 30% slopes. A second research site must be selected this year.

Presently there are no publications resulting from this work, but manuscripts are being prepared and two papers will be presented at the Soil Science Society of America meeting.

Work Planned for Next Year: Fahmuddin Agus will complete his dissertation and prepare four or five scientific manuscripts on the research before returning to his home in Indonesia in March.

Currently we are identifying additional research collaborators at IRRI; they likely will be Thomas George and Guy Trebuil. Bir Thapa and I will travel to the Philippines in early 1994 and, working with Ken Cassman and these collaborators, will select a steepland research site in Matalom, Leyte and develop a detailed work plan to address soil management of steep upland soils to optimize soil water use and protect soil resources. In addition, Thapa and Cassel will travel to Claveria to take final soil and plant measurements at the site where the preliminary study began.

April Horowitz will begin working toward her M.S. on this project in August. Goals are to evaluate several indigenous and experimental soil management systems on the steeplands, with emphasis on soil properties and soil erosion (40 to 80+% slope) near La Ceiba, Honduras, on the humid tropical Atlantic Coast. Collaborators in Honduras are yet to be identified. Currently we have been discussing this cooperative effort with Ron Knapp and Paul Moreno, leaders of the CIAT Steeplands Program.

Research Sites:

Claveria, Mindanao, Philippines
Matatom, Leyte, Philippines
Atlantic coastal region of Honduras

Budget:

Total Funding Source, US $1000's

OBJECT	CRSP	EXTERNAL	MATCHING	HOST	TOTAL
Salaries	36.0	0.0	17.4	12.0	65.4
Fringe Benefits	1.8	0.0	4.2	0.0	6.0
Tuition Remission	16.5	0.0	0.0	0.0	16.5
Allowances	2.7	0.0	0.0	0.0	2.7
Consulting	0.0	0.0	0.0	0.0	0.0
Travel, US	2.0	0.0	0.0	0.0	2.0
Travel, Int.	12.8	0.0	0.0	0.0	12.8
Supplies	4.8	0.0	0.0	2.0	6.8
Equipment	2.0	0.0	0.0	1.0	3.0
Communication	3.6	0.0	0.0	0.4	4.0
Shipping/Freight	2.4	0.0	0.0	0.0	2.4
Publication	0.0	0.0	0.0	0.0	0.0
Other Direct Costs	2.1	0.0	0.0	2.0	4.1
Indirect Costs	22.0	0.0	5.6	0.0	27.6
Total	108.7	0.0	27.2	17.4	153.3

Special Budget Requirements:

Equipment to make field installations for runoff and sediment collectors at the new field site in Matalom, Leyte are needed. A tension infiltrometer, estimated cost not to exceed $2000 is requested to characterize effects of soil structural on water movement.

Human Resource Commitments:

Full Time Equivalents (FTE)

INSTITUTION	SCIENTISTS SENIOR	SCIENTISTS JUNIOR	TECHNICIAN	ADM. SUPPORT	OTHER	TOTAL
US	0.10	2.50	0.19	0.16	0.0	2.95
Host	0.15	0.25	0.05	0.10	0.0	0.55
Other	0.0	0.0	0.0	0.0	0.0	0.0
Total	0.25	2.75	0.24	0.26	0.0	3.50

Narrative explanation of human resources:
Fahmuddin Agus, Bir Thapa and April Horowitz are junior scientists working on the project. Collaborations for the steeplands research in Honduras will be identified in the near future upon a follow-up to initial discussions on project activities.

Date Initiated: April 17, 1991

Expected Completion: December 1997

Signatures:

D.K. Cassel TJS 6-10-93
Principal Investigator Date

T.G. Smyth 6-10-93
Program Coordinator Date

Principal Collaborator Date

Institutional Administrator Date

North Carolina State University

College of Agriculture and Life Sciences
Academic Affairs, Extension & Research

Department of Soil Science
Box 7619, Raleigh 27695-7619
(919) 515-2655
FAX: (919) 515-2167

February 8, 1993

Dr. Ron Knapp
Programa de laderas
Apdo. 6713
CIAT
Cali, Columbia
Phone: 57-23-675050
FAX: 57-23-647243

Dear Dr. Knapp:

I appreciate you taking the time last Thursday, February 3, to discuss with Jot Smyth and myself the current stage of development of the CIAT steeplands program. The sharing of information was excellent and we have a better understanding of CIAT's intentions as far as steepland research sites are concerned. We look forward to additional information from you as soon as it becomes available. Jot and I are looking forward to developing collaborative research with CIAT at one or more of the steepland locations. We are particularly interested in the La Ceiba site in Honduras. Hopefully in the near future we can interact at the personal level to develop specific research goals and projects.

As I indicated during our phone conversation, I am faxing to you the 'Annual Activities Work Plan and Budget' for 1991-92 and 1992-93 periods for project NCSU 6 entitled "Processes of Soil Degradation and Rejuvenation under Different Land Use Systems". Research on this project up to the present time has been conducted in the Philippines, but I would like to expand this effort in the La Ceiba area. Please feel free to forward this material to Raul Moreno if you wish.

We look forward to the development of this collaborative effort.

Sincerely,

D. K. Cassel

D. K. Cassel
Professor of Soil Science

cc:Dr. Jot Smyth

North Carolina State University is a land-grant university and a constituent institution of The University of North Carolina.

TO Dr. Jot Smyth
Dr. D.K. Cassel
Professor of Soil Science
NCSU
Raleigh, NC 27695-7619

FROM Dr. Ron Knapp, CIAT

DATE 8March93

Dear Keith and Jot,

Sorry for the delay in responding to your fax and letter. (I just returned from a GIS conference and Trade Show in Vancouver).

The hedgerow study is looking as if it will be a priority for us here in Colombia. In fact a German project from Hohenheim, is in place to evaluate germplasm.

I'm interested in expanding the project to look at computational models to predict the formation and evolution of the terraces. We should keep in touch on that.

Regarding the legume work in Honduras, Raul will be here next week so I will have a chance to talk to him a bit more. (He already has your and Jot's names and will be in touch with you.)

The maize-macuna rotation seems to be bery popular. There is a Cornell student working with J.MT. Pleasant on the fertility side, ie, N. Carryover.

I'll get back to you after I talk to Raul.

Regards,

RON

*** Delivered via DIALCOM Facsimile service ***

SOIL MANAGEMENT CRSP
ANNUAL ACTIVITY WORK PLAN AND BUDGET REQUEST

Fiscal Year: 1993-1994

Project Number: CU-04b

Title: Development of Management Practices To Reduce the Impact of Surface Crusts on Water Storage in the Root Zone

Global Thrust: Natural Resources Management, Sustainable Agriculture

Constraints Addressed:
Primary - inadequate resource information, landscape restrictions.
Secondary - Soil physical limitations, water stress

The surface horizon of the ferrallitic soils of the Terres de Barre, in southern Ghana, Togo and Benin, presents a very coarse texture and a clay fraction dominated by kaolinite and Fe compounds. The organic matter (O.M.) of :n is less than 1% as a result of cultivation. It is well known that low O.M. contents can adversely affect the soil structure and hence the infiltration capacity of a soil. In the case of the T. de B., one might think at first that the coarse texture would compensate for the poor surface structure of the cultivated soils. Indeed, such soils can easily absorb extremely heavy rainstorms if their surfaces are protected from drop impact. However, despite the coarse texture, the infiltration capacity of the soil greatly decreases when the soil surface is directly exposed to drop impact. This is attributed to the formation of a crust at the surface of the soil, and the lack of O.M. is thought to be largely responsible for the occurrence of the surface crusts.

Currently land degradation in the form of soil crusting and erosion appears to be a common occurrence on the T. de B. The problem is not a new one, since studies focussing on this problem were started on the T. de B. of Benin as early as 1964 (Verney *et al.*, 1967, cited in Poss *et al.*, 1990). Soil crusting is a primary concern in agricultural systems because of its effects on water infiltration, runoff and erosion and the adverse effects it has on seed emergence.

Periods of water deficit are a common occurrence during the growing season. During these dry periods, plants must rely on the water stored in the root zone for their water supply. The amount of water available in the profile depends on the water retention capacity of the soil profile but also on the amount of water that actually infiltrated into the soil before the dry spell. If the infiltration capacity is always higher or equal to the rainfall intensities, only the rainfall distribution and retention capacity of the soil would determine the availability of water. This would be the case for soils that still have a good surface structure or those whose surface is protected from rain drop impact. More generally, the infiltration capacity of the soil is limited by the occurrence of a surface crust. When water transmission through the crust is less than the rainfall intensity, runoff occurs. The relative importance of crusting then depends on how much water is lost by runoff over the course of the growing season and on

how much of that water would have been available to plants had it totally infiltrated into the soil. Unfortunately, the second part of that question has not yet been answered. However, previous studies have demonstrated the significance of water losses by runoff. Poss et al. (1988) noted that for heavy simulated rainstorms on $1m^2$ plots, the runoff coefficient (ratio of water lost by runoff to total rainfall) could reach values of 50% or more in southern Togo. The studies of Verney *et al.* (cited in Poss *et al.*, 1988) on 10x30 m^2 erosion plots on the T. de B. of Benin (Cotonou) revealed that almost 20% of the yearly rainfall was lost in the form of runoff (average over five-year period). Although extrapolation of these numbers to Togo should be done with care (annual rainfall at Cotonou is 1400 mm versus 900 mm in southern Togo), the order of magnitude does provide some insight as to the possible importance of water loss by runoff. It would seem, therefore, that any practice that would maintain a high permeability or improve the permeability of the soil surface could possibly decrease the length of the periods of water deficit, provided the soil is capable of storing the additional water within the root zone of the crops.

Principal Investigators and Institutions:

Philippe Baveye - Cornell University, Ithaca, New York
Soklou Worou - Institut National des Sols, Lome, Togo
Dr. A. Casenave - ORSTOM, Niamey, Niger

Collaborators and Institutions:

Charles Bielders - Cornell University, Ithaca, New York
Diego de Lozada - Cornell University, Ithaca, New York
Ezoun Mathe - Institut National des Sols, Lome, Togo

Objectives: A number of methods aimed at controlling crust development by means of improving aggregate stability have been described in the literature. These are most often based on the use of either some form of chemical ($CaCO_3$, $CaSO_4$, synthetic organic polymers, ...) or on some form of organic matter (crop residues, fallow period, manure, . . .). For economic reasons the use of chemicals seems of little practical interest in the present case because most farmers cammpt evem afford nitrogen fertilizers. This doesn't mean that such an approach should be ignored altogether, but results from such a study are unlikely to affect Togolese farmers in the near future. The use of organic matter (O.M.) as a means of improving structural stability often is advocated in western agriculture. Some measurements done on the T. de B. have shown, however, that soils left with a natural fallow for several years do not show significant improvement in their physical properties (Poss *et al.*, 1990). Furthermore, implementation of a fallow period during crop rotation seems rather unrealistic at present since this practice is increasingly abandoned as a result of population pressure. The recycling of crop residues as a way to restore O.M. content of the soil and protect the soil surface from drop impact may be a possibility, although these residues are often used by farmers for other purposes. Protecting the surface from drop impact with the crops themselves is also a possibility, but such a practice will not be effective at the start of the growing season when the initial crusting takes place.

A last set of possible solutions is based on the development of tillage practices that would mainly require labor input, the only resource that may be available to farmers at this point. The development of such practices will require a clear understanding of the interactions between soil properties, soil crusting and infiltration. The actual purpose of such practices may not be to prevent crusting per se but to take advantage of the various crust morphologies—and their corresponding permeabilities—observed in the field to reduce runoff at the scale of a field and to favor infiltration locally. This last approach is the focus of the present proposal .

Several studies already have been concerned with the problem of crusting on the T. de B. These studies have all revealed the existence of different types of crusts at the $<1m^2$ scale. Valentin (1985) classifies these crusts as structural, erosion-, runoff- and depositional crusts. The crust morphology was observed to be strongly related to its topographical position on the soil microrelief. There is also some evidence suggesting that the various crust types have very different permeabilities, but the relative permeabilities of these various crusts and their influence on the infiltration process have never been determined in a systematic way. The use of certain tillage practices most likely will not limit crusting. However, by modifying the surface microrelief, these practices will change the relative or real extension of a certain type of crust with respect to the others. If the permeabilities of the various crust types and the way by which they control infiltration are known, it would seem possible to devise a tillage practice that would maximize the extension of the most permeable crust, *i.e.*, maximize infiltration.

Maximizing infiltration may not be our sole concern. It must also be determined whether the distribution of water in the soil profile will be homogeneous during an infiltration process. Up to now, infiltration through a crust almost always has been associated with a homogeneous wetting front under field conditions, but the movement of water below a crust is still poorly understood. It certainly has never been studied in the case of the T. de B. The reason for mentioning this point is that a preliminary experiment performed during the summer of 1990 revealed that only ~20% of the soil area effectively contributed to water infiltration. This implies that in addition to limiting water infiltration, crusting may also limit the volume of soil that will store water. Preferential flow, by concentrating water flow in a limited volume of soil, increases the risk of water loss by deep percolation out of the root zone. The above-mentioned finding emphasizes the necessity to understand the ways by which the particular types of crusts of the T. de B. control infiltration. The tillage practice that is to be developed under the constraint of maximizing infiltration must now also take into account the homogeneity of water distribution in the soil profile, in accordance with the water retention capacity of the soil.

There is a possible advantage in considering tillage practices for controlling infiltration rather than working on ways to limit crust formation. A crust, by definition a low porosity/low permeability layer, will act as a natural mulch and strongly reduce water evaporation from the surface. This may also help in reducing the severity of periods of water deficit.

The final objective of this research is to arrive at a clear understanding of infiltration and water retention in the cultivated soils of the T. de B. Such an approach will require:

- A thorough description of the soils from the physical but also physico-chemical point of view. Soil porosity will be extensively investigated for every horizon as it controls water retention and movement.
- Investigation of causes for the stability or lack of stability of the soil structure. For this purpose, soil samples will be subjected to combinations of chemical and physical treatments. Samples from secondary forest and long-term fallow plots will be used as well. A comparison of samples of various origins may provide better insight into the processes of degradation taking place during cultivation.
- An integrated description of crusting on field plots detailing the crust morphologies, their evolution, distribution and hydraulic properties. A set of laboratory experiments will complement the field rainfall-simulation experiments.

With these factors in mind, tillage practices designed to enhance water infiltration and availability to plants may be proposed. The tillage practices will take into consideration the limited equipment available to farmers. Field experiments will be conducted to test whether the proposed tillage practices meet their goals.

Progress Report: During the spring and summer of 1992, a first set of field experiments was carried out on the Terres de Barre of southern Togo (cf. trip report, September 1992). Those experimental investigations were designed to assess whether water infiltration into a surface-crusted soil could depart from the general assumption of spatially homogeneous infiltration. In the event of spatially non-homogeneous infiltration, sampling and monitoring procedures were developed to provide insight into the conditions and mechanisms leading to such an infiltration pattern. The results of these investigations have been summarized in a poster presented at the annual meetings of the ASA/SSSA in Minneapolis in November 1992.

Because of experimental difficulties and since the range of conditions under which spatially non-homogeneous infiltration was observed appeared to be more narrow than expected, no definite answers could be proposed as to the exact mechanisms involved in the process. Therefore, a second set of field experiments was planned for the Spring of 1993. This second field investigation never took place however, for reasons explained below.

Since the end of 1989, Togo has known increasing political instability because of a strong pressure to change the country's political system from a single-party to a multi-party system. A political transition period due to end in August 1992 with multi-party elections was characterized by internal political and street violence. Though this condition frequently delayed our work plans, it was still possible to perform field experimentation under reasonable conditions. For several reasons, the August elections were postponed until December 1992, and finally canceled altogether. This resulted in a national strike that started in December 1992 and lasted several months, already seriously jeopardizing our chances of obtaining in time from the Togolese Ministry of Scientific Research the necessary permissions to do field work. Since then,

strong political violence in the capital city, Lome, has been reported. These events and the failure of the current regime to discuss the political evolution of the country with the opposition parties during a meeting in France, resulted in the French government's decision to stop all cooperation aid with Togo. This lead to the official closing of the ORSTOM center of Lome, with all researchers being sent back to France.

The present research effort in Togo was very much dependent on the infrastructure provided by ORSTOM. The centerpiece of the experiments, the rainfall-simulator, was provided by the ORSTOM center. The center also provided many other pieces of equipment, as well as laboratory space and transportation. Considering that by the end of March, political violence was still rising and a major exodus was affecting southern Togo, that the necessary authorization for research had not been obtained, and that support from ORSTOM was no longer available, the projected field research was canceled. Relocation to another site in another country did not seem to be a viable alternative considering the effort and especially the time that would be involved in such an endeavor. It is indeed still our goal to end the present research project by the summer of 1994.

Under these conditions, it seems impossible not to drastically reorient the current research project on the Terres de Barre of southern Togo. The scale of the field experiments carried out in Togo does not allow for reproduction under laboratory conditions. Therefore, the focus of our research will be shifted from non-uniform-infiltration-oriented experiments to experiments providing additional information on the microscopic processes involved in crust formation. Some laboratory experiments will still be carried out that should give better insight into the field experimental results acquired in Togo. An overview of the projected experiments is given below.

In parallel with these research efforts in Togo, and partially because of the political problems in this country, we have also tried to find another suitable location where we could carry out field research on the degradation/rejuvenation of agricultural soils subject to crusting. Last September, we received an invitation from the Bolivian government to visit the area around Tiwanaku, on the Altiplano close to Lake Titicaca. In the last fifteen years, a group of archaeologists, with the assistance of some local agronomists, have restored indigenous raised beds that were in production from roughly 1,000 B.C. to around 1,000 A.D. but were abandoned since for reasons that are not entirely clear. These raised beds allow farmers to obtain yields that are substantially (up to ten times) higher than those in neighboring fields, where water deficits and frosts frequently kill the crops.

Since September, the USAID mission has awarded us a $63,000 grant to purchase the field equipment needed to monitor the water- and heat-transport dynamics in reconstructed raised beds. The Bolivian government has also has agreed to provide manpower (50 soldiers for 3 months) to reconstruct the fields, while the Interamerican Foundation has agreed to provide $32,000 to support Bolivian "thesistas" (graduate students working on a Master's thesis) to collaborate with our research effort. Finally, the Cornell International Agriculture Center (C.I.I.F.A.D.) will contribute an additional $30,000 to strengthen the pluridisciplinary character of the project; we hope in the near future to have join the project an agricultural economist who would study in detail the economic feasibility of the large-scale rehabilitation of

raised beds on the altiplano or an anthropologist who would analyze the response and reactions of the farmers to the reintroduction of the ancestral raised-bed technology.

An aspect of the raised-bed technology that needs further study and may provide some insight into the question of why these raised beds were abandoned around 1,000 A.D. is the formation of crusts on the platforms of the raised beds. In Bolivia as well as in the neighboring part of Peru (near Puno), we have observed many instances of these surface crusts. They seem to be caused by the accumulation of salts at the soil surface, which is consistent with the level of salinity of the water of Lake Tititcaca. In the coming few months (especially during a trip that P. Baveye will make in October), we plan to develop a series of short experiments, in the field and in the laboratory in Ithaca, to study this crusting problem in more detail. This work will be done in collaboration with Dr. Vladimir Orsag, a Bolivian soil physicist associated with the Bolivian-Peruvian binational organization SUBCOMILAGO.

Work Planned for Next Year:

1. To complement the field experiments of last year in Togo, infiltration experiments will be carried out in the lab on soil columns with various surface morphologies (flat/convex/concave). Such surface morphologies are known from previous field and lab experiments to result in different surface crust morphologies. The aim of such experiments is to assess whether these various crust morphologies have significantly different hydraulic properties so as to induce a non-homogeneous infiltration patterns.
2. Experiments will be carried out to try to better understand the conditions of formation of the clay skin and washed-in zones observed in thin sections of field and lab crusts:

    - By working with artificial mixtures of sand, silt and clay the effect of the skeleton grain size distribution will be studied. The clay fraction of the alfisols from southern Togo will be used in these mixtures, the silt and sand fractions being quartz as in the original soils. Both very narrow and broad grain size distributions will be used.
    - Mixtures of varying bulk density but identical textural characteristics may provide better insight into the importance of surface compaction by drop impact on the depth of accumulation of the clay skin. It has been proposed that this depth is linked to the depth to which the surface material is compacted by drop impact. This hypothesis may be checked by working with mixtures of maximum density that should therefore not be further compacted by subsequent drop impacts. Working with drops of differing kinetic energy may also provide additional information about the importance of depth of compaction by drop impact in the depth of clay accumulation. Columns with artificial layers of varying bulk density will also be considered for this effect.
    - The relative importance of clay dispersion and mechanical sieving in clay skin formation will be checked by working with simulated-rainfall water of varying composition and ionic strength, well above and well below the flocculation value of the clay fraction. Rain of different kinetic energy will also be

considered. The conditions for washed-in layer formation will also be investigated.

- An experiment—still to be defined more precisely—will be carried out to assess the stability of the clay skin when exposed at the very surface of the soil in an erosion crust. It has been argued that the erosion crust is the result of deposition at the end of a rainfall event, because such a thin layer would be unlikely to resist direct high energy drop impact and remain intact. The morphological evidence available so far does not support that hypothesis, yet the reason for maintaining 0.1 mm clay skin at the soil surface during rainfall events is unclear.

3. Most of the above experiments will be complemented with morphological analysis of the crusts by visual observations on thin sections, image analysis when appropriate, and SEM/TEM observations. For instance, close observation of the clay orientation in the clay skin should provide clues as to the dominant process involved in its deposition. Image analysis of SEM images of polished sections can provide semi-quantitative information about particle segregation or compaction effects at the soil surface, since these images provide very good detail of skeleton grain arrangement.

   When appropriate, the morphological analyses will be complemented with permeability measurements.
4. Because of the rather drastic and recent change in focus for this research project, it is most likely that additional experiments will be defined over time as new questions arise.

Calendar of Events

EVENT	DATE
Laboratory experiments	September 1993-May 1994
Presentation of results of crust morphological analysis at the A.S.A./S.S.S.A. meetings in Cincinnati	November 7-12, 1993
Final laboratory experiments and thesis writing	May 1994-August 1994
Thesis defense	August 1994

BUDGET (93-94): CU-04b

OBJECT	TOTAL FUNDING SOURCE CRSP	EXTERNAL	MATCHING	HOST	TOTAL
Salaries					
GRA (2.0) Stipend	25,908				25,908
GRA (2.0) Fees	8,536				8,536
Baveye (25%)			12,275		12,275
Administrative Support	500				500
Fringe Benefits @28.97%	145				
Matching F.B. @ 36.78%			4,515		4,515
Allowances (GRA & PI)*	7,000				7,000
Visiting Scientist	2,000				2,000
Consulting					
Travel					
US	1,600				1,600
International	5,000				5,000
Supplies	4,000				4,000
Equipment	5,000				5,000
Equipment Maintenance					0
Telecommunication					1,000
and Copying	1,000				2,000
Analytical Costs	2,000				
Publication	1,000				
Labor (off-campus)*	2,500				
TOTAL DIRECT COSTS	66,189		16,790		82,979
Indirect Costs					
On-Campus	23,303		9,066		32,369
Off-Campus (* = Off-Campus)	2,850				2,850
TOTAL PROJECT COSTS	92,341		25,856		118,198

INSTITUTION	FULL TIME EQUIVALENTS (FTE) SCIENTIST SENIOR	JUNIOR	TECHNICIAN	ADM. SUPPORT	OTHER	TOTAL
US	0.25	2.00	0.50	0.04		2.29
HOST	0.50					1.00
OTHER						0.00
TOTAL	0.75	2.00	0.50	0.04		3.29

Date Initiated: September 25, 1990

Expected Completion: September 24, 1994

SOIL MANAGEMENT CRSP
ANNUAL ACTIVITY WORK PLAN AND BUDGET REQUEST

Fiscal Year: 1993-1994

Project Number: TAMU-05

Title: Integrated Management of Small Agricultural Watersheds and Agroforestry Systems

Global Thrust: Natural Resources Management

Constraints Addressed: Climatic variability, landscape restrictions, production-demand pressure, inadequate resource information.

Principal Investigators and Institutions:
A.S.R. Juo - TAES, Texas A&M University
A. Manu - TAES, Texas A&M University
T. L. Thurow - TAES, Texas A&M University

Objectives: The overall goal of this project is to develop and adapt sustainable agricultural watershed management and agroforestry technologies by the evaluation of appropriate strategies that integrate socioeconomic constraints and improved technology components of soil fertility management, soil moisture management, soil conservation and crop/fodder/tree-crop production. At present, this project consists of four subprojects:

TAMU-05-A Soil and Water Conservation on the Hillside Farming Systems in Southern Honduras

TAMU-05-B The Effect of Plant Density on the Growth, Yield, Light Interception and Water Use of a Sorghym-Cowpea Intercrop in

TAMU-05-C Above- and Below Ground Competition and Nutrient Cycling by Subsoil Nutrient Acquisition in Alley Cropping Systems

TAMU-05-D Integrated Management of Agricultural Watersheds in Niger

Participating collaborators, specific objectives, progress reports, planned activities and proposed budgets are provided under each subproject.

Budget (93-94): TAMU-05

Object	CRSP	External	Matching	Host	Total
Salaries	63,325.99	32,050.00	23,709.00		119,084.99
Fringe benefits	19,864.68	9,506.00	6,688.00		36,058.68
Allowances	0.00	2,000.00			2,000.00
Consulting	0.00	7,760.00			7,760.00
Travel, US	2,515.59	0.00			2,515.59
Travel, INT	14,631.17	4,500.00			19,131.17
Supplies	9,423.38	13,300.00			22,723.38
Equipment	9,200.00	16,000.00			25,200.00
Communications	1,105.59	3,000.00			4,105.59
Shipping/Freight	2,700.00	3,000.00			5,700.00
Publications	1,207.79	4,000.00			5,207.79
Other direct costs[b]	2,500.00	3,500.00			6,000.00
Indirect costs	47,382.70	0.00	13,070.71		60,453.41
TOTAL	173,856.89	98,616.00	43,467.71	0.00	315,940.60

Human Resource Commitments:

	Full Time Equivalents (FTE)					
Institution	Senior Scientist	Junior Scientist	Technician	Admin. Support	Other	Total
US	0.60	1.50	0.45	0.32		2.87
Host	0.40		3.00	0.20		3.60
Other	0.20		2.00			2.20
Total	1.20	1.50	5.45	0.52	0.00	8.67

Date Initiated: November 1, 1990

Expected Completion: September 24, 1994

Signatures:

Project Leader	Date	Program Coordinator	Date

TAMU-05 DESCRIPTION OF SUBPROJECTS

Subproject Number: TAMU-05-A

Title: Soil and Water Conservation on the Hillside Farming Systems in Southern Honduras

Collaborators and Institutions:

T.L. Thurow - TAES, Texas A&M University
A.S.R. Juo - TAES, Texas A&M University
J. Jordan - USAID/Honduras, Land Use and Productivity Enhancement Project (LUPE), Ministry of Natural Resources
J. Smith - Texas A&M University
J. Mayorga - LUPE Project, Ministry of Natural Resources, Honduras
J. Salas - LUPE Project, Ministry of Natural Resources, Honduras

Objectives: Intensive cultivation of steeplands in southern Honduras results in severe soil erosion and runoff. Severe soil erosion results in decreased productivity and increased frequency of drought stress on the fields and increased siltation problems downstream. In addition to detaching and transporting soil, increased runoff increases risks of downstream flooding, reduces base flow of streams and causes marked swings in the salinity gradient of coastal ecosystems (*i.e.*, has a negative impact on the region's chief hard currency crop by reducing shrimp production and also negatively affects other wetland organisms). Hydrologic studies are urgently needed to document and refine/develop economically and environmentally sound soil and water conservation strategies suitable for implementation on these steepland cultivation systems.

The objective of this research is to assess the effectiveness of some of the promising soil and water conservation techniques identified by LUPE (*e.g.*, grass strips, rock walls and agroforestry). Data gathered in this effort will be used to develop guidelines that will optimize the field implementation of these techniques. Beyond meeting the needs of the natural resource field managers, the data will also provide the basis for planners, economists and administrators to gain more complete understanding of the value of a project such as LUPE in terms of maintenance of on-site production and reduction of downstream problems associated with siltation and flooding.

Progress Report: In response to the request of host country collaborators, a research project addressing steepland soil and water conservation was initiated in collaboration with the Honduran Ministry of Natural Resources, INTSORMIL, USAID/LUPE and the Pan American School of Agriculture. Joint planning of this project has been underway since the signing of the MOA with the Ministry of Natural Resources in January 1992. In October 1992, T. Thurow traveled to Honduras to discuss local funding support and to select additional watershed sites for long-term hydrological and sedimentation studies. The outcome of this visit was the establishment of the subproject herein described.

This subproject is jointly supported by TropSoils, LUPE, MNR and USAID-Tegucigalpa. In-kind support is also provided by INTSORMIL and Pond Dynamics CRSP's and Escuela Agricola Panamericana in Honduras. Following is a chronological synopsis of activities during 1993.

2/93 Flumes, stage recorders, sediment samplers and intensity rain gages were purchased and shipped to Honduras. USAID processed and financed customs clearance.

3/93 LUPE personnel located several potential sites at which the equipment could be installed. These sites are typical of the steepland sites (50-70% slopes) that are the focus of LUPE activities in the region.

4/93 T. Thurow and technician worked with LUPE personnel and farmers to install the equipment at the field sites.

5/93 Data collected by LUPE technicians from the onset of rains (3 May) until arrival of the TAMU graduate student (24 May). Graduate student begins intensive field data collection on the study sites. Two studies are conducted in conjunction with this research:

1. Quantification and analysis of runoff, erosion, nutrient loss and crop response associated with LUPE-recommended soil and water conservation technologies. Very little information on runoff, sediment yield and nutrient loss are available from steepland farming systems in the tropics. This first year of data will actually quantify the magnitude of the problem. Even though the catchments will be selected to be as similar as possible, each catchment will have some unique characteristics that will affect hydrologic response. Therefore, this first year of data will also provide the necessary baseline calibration for determining the improvement in soil and water conservation associated with implementation of LUPE-recommended technologies.
2. Relative comparison of LUPE soil and water conservation technologies already in place. Soil erosion and additional site responses to the conservation technologies will be documented on research sites utilized by M. Thompson (M.S. Thesis, 1992, TAMU). Additional characterization of soil properties and crop yields associated with conservation technologies will be conducted.

Work Planned for Next Year: Two of the three catchments will each have a different soil and water conservation practice installed using typical LUPE procedures. The material and labor costs will be estimated for each catchment. The third catchment will continue to be farmed using traditional methods. This traditionally farmed field will serve as the benchmark for comparison with the baseline data collected from all three sites in 1993.

Soil and crop cover and yield data in all three catchments will continue to be monitored by J. Smith, who also will continue to collect data on runoff, sediment and nutrients. These data will be used not only to help determine what changes have occurred in hydrology and erosion in response to installation of LUPE technologies but also to help interpret why the changes have occurred. This understanding should help

refine existing erosion and runoff prediction techniques to better suit steepland tropical farming systems and may provide insight into how to refine the LUPE technologies to optimize the soil and water conservation attributes that are most effective.

Calendar of Events

EVENT	DATE
LUPE technologies installed on two of the catchments	March - May 1994
Monitor the sites as described above	May - July 1994 and 1995

Research Site: 15 km southeast of Choluteca, Honduras

Budget (93-94): TAMU-05-A

Object	CRSP	External[a]	Matching	Host	Total
Salaries	13,976.45	18,750.00	5,461.00		38,187.45
Fringe benefits	4,590.46	5,250.00	1,541.00		11,381.46
Allowances	0.00	2,000.00			2,000.00
Consulting	0.00	0.00			0.00
Travel, US	636.31	0.00			636.31
Travel, INT	4,272.61	1,000.00			5,272.61
Supplies	1,704.46	1,800.00			3,504.46
Equipment	0.00	16,000.00			16,000.00
Communications	256.31	0.00			256.31
Shipping/Freight	0.00	0.00			0.00
Publications	68.15	4,000.00			4,068.15
Other direct costs[b]	2,500.00	3,500.00			6,000.00
Indirect costs	12,042.04	0.00	3,010.86		15,052.90
TOTAL	40,046.79	52,300.00	10,012.86	0.00	102,359.65

[a]External contributions are those of LUPE and include LUPE technician salaries (2) and local travel in Honduras, lodging support of TAMU graduate student while in Honduras, field labor, supplies, the use of a vehicle and publication/workshop/training costs. In-kind support is received from INTSORMIL CRSP and Pond Dynamics CRSP.
[b]Field labor costs associated with installation of conservation practices and local data collection.

Subproject Number: TAMU-05-B

Title: The Effect of Plant Density on the Growth, Yield, Light Interception and Water Use of a Sorghum-Cowpea Intercrop in Mali

Collaborators and Institutions:

Samba Traore - Cinzana Station, L'Institut d'Economie Rurale (IER), Mali
Zoumana Kouyate - Cinzana Station, L'Institut d'Economie Rurale (IER), Mali
R. Gilbert - TAES, Texas A&M University
J.L. Heilman - TAES, Texas A&M University
A.S.R. Juo - TAES, Texas A&M University

Samba Traore of the Cinzana Station, IER, Mali will supervise the agronomic research in Mali. Mr. Robert Gilbert, TropSoils Graduate Research Assistant, TAMU, will be responsible for conducting the experiment at the Cinzana Agronomic Research Station, Mali.

Objectives: Intercropping, the growing of two or more crops simultaneously in the same field, is a common practice in Africa. In Mali, various crop combinations involving sorghum, pearl millet, cowpea and groundnut are used in local farming systems. Intercropping systems are often used by Malian farmers to ensure cereal and legume yield stability. However, the value of cowpea as a dry season fodder makes it desirable to use intercropping systems to maximize cowpea production while maintaining stable sorghum yields, thus providing a more sustainable agricultural system with increasing population densities. Recent research by INTSORMIL in Mali has shown that intercrops and legume rotations can increase subsequent cereal yields. However, there is a need to study ways of maximizing cowpea production while maintaining sorghum yield.

The proposed experiment would study the growth and yield of cowpea and sorghum in several intercrop densities at Cinzana, Mali. The objectives would be to:

1. Determine the cropping system that maximizes cowpea yield (profit) without decreasing sorghum yield (staple food);
2. Measure light and water use to determine the intercrop density that provides the optimal light and water regime for cowpea production; and
3. Determine if the intercrops use environmental resources (*i.e.*, light and water) more effectively than sole crops.

One of the treatments will examine the local farming system (25,000 sorghum ha^{-1}, 10,000 cowpea ha^{-1}, cowpea planted 3 to 4 weeks after sorghum in the same row), while other treatments will vary the sorghum/cowpea densities.

Progress Report: This project is in the initial stages of development. An experimental outline was sent from TAMU to IER in Mali on May 14, 1993, requesting a collaborative dialogue on the field experiment. In addition, a separate field experiment is being conducted in the summer of 1993 at TAMU to characterize the surface energy

balance of a sorghum/cowpea intercrop with a density similar to that of the local Malian farming systems.

Work Planned for Next Year: The proposed experiment will be a collaborative effort between TAMU and IER/Cinzana, Mali. The experiment will commence in May 1994 and last for one cropping season. Mr. Samba Traore, IER/Cinzana, and Mr. Robert Gilbert, TAMU, will be jointly responsible for the field operations. Land preparation will begin in mid-May at approximately the same time as Mr. Gilbert arrives in Mali. The sorghum will be planted first in all the intercropping treatments in early June by the Cinzana field staff. Mr. Gilbert will be responsible for the installation of weather station equipment, PAR sensors and neutron probes at this time. Mr. Gilbert will also be responsible for collecting weekly plant growth samples with the help of the Cinzana field staff supervised by Mr. Traore.

The cowpea crop will be planted 3 to 4 weeks after the sorghum in all treatments near the end of June. Mr. Gilbert will be responsible for the cowpea (September 1) and sorghum (October 1) harvests with help from Cinzana field station personnel. Final data processing will be conducted by Mr. Gilbert using computers at the Cinzana station.

Research Sites: Cinzana Research Station, Mali

Budget (93-94): TAMU-05-B

Object	CRSP	External	Matching	Host[a]	Total
Salaries	14,298.49	0.00	6,105.00		20,403.49
Fringe benefits	4,768.13	0.00	1,722.00		6,490.13
Allowances	0.00	0.00		0.00	0.00
Consulting	0.00	0.00			0.00
Travel, US	658.52	0.00		0.00	658.52
Travel, INT	3,817.03	0.00			3,817.03
Supplies	3,237.77	0.00			3,237.77
Equipment[b]	4,200.00	0.00			4,200.00
Communications	308.52	0.00			308.52
Shipping/Freight	1,200.00	0.00			1,200.00
Publications	79.26	0.00			79.26
Other direct costs	0.00	0.00			0.00
Indirect costs	12,198.11	0.00	3,365.61		15,563.72
TOTAL	44,765.83	0.00	11,192.61	0.00	55,958.44

[a]Host contributions have yet to be determined.
[b]Proposed instrumentation to be funded by SM-CRSP includes fourteen Licor LI-190 quantum sensors, ($300 each) to characterize light interception by the cowpea and the sorghum in the intercropping experiment. A data logger, leaf area index meter and infra-red thermometer are being provided by TAMU.

Subproject Number: TAMU-05-C

Title: Above- and Below-ground Competition and Nutrient Cycling by Subsoil Nutrient Acquisition in Alley Cropping Systems

Collaborators and Institutions:

J. Caldwell - TAES, Texas A&M University
A.S.R. Juo - TAES, Texas A&M University
T.L. Thurow - TAES, Texas A&M University
B.T. Kang - International Institute for Tropical Agriculture (IITA), Ibadan, Nigeria

This research is in the planning stage. The institutions to be contacted are IITA, Nigeria and Cameroon, and International Centre for Research in Agroforestry (ICRAF). These institutions may be asked to provide field locations for the proposed research as well as for technical and financial assistance.

Objectives: Soil loss and degradation are primary factors in decreasing crop production in the Tropics. To reduce the impact of these processes and sustain or increase food supplies, a cropping pattern of growing trees with annual crops—known as alley cropping—has been researched and promoted. Under certain circumstances this system has been shown to increase yields, reduce runoff and increase the nutrient content of the surface soil.

One of the suspected advantages of this system is "nutrient pumping," *i.e.*, absorption of essential nutrients from the sub-soil beneath the rooting depth of the annual crop. If prunings from the trees are applied to the soil, these nutrients can then be released and become available to the annual crop. This is an important process, since it can contribute to the sustainability of the system. However, nutrient pumping has been demonstrated only circumstantially and never directly proven to occur in alley cropping.

Growing trees in close proximity with crops inevitably results in competition for resources both above and below ground. In alley cropping it is not clear to what extent this competition occurs or whether competition above or below ground is the most important in determining yield. This research will provide important information regarding the choice of management practices to minimize adverse competition.

Specific objectives of the study are to:

1. Determine the extent of sub-soil nutrient acquisition by alley cropped trees using radioactive tracers; and
2. Quantify different management practices in alley cropping on above and below ground competition by:

   - determining energy balance under different management practices;
   - determining competition for solar radiation; and
   - determining competition for soil moisture.

Progress Report: The initial proposal for research is in the final stages and will be completed by June 21 for consideration.

Work Planned for Next Year:

Calendar of Events

EVENT	DATE
Completion of research proposal and submission to committee.	Present - June 21, 1993
Communications with IITA and ICRAF about proposed research and possible collaboration. Research proposal will be adapted to fit the response received from these institutions.	June 21 - July 31, 1993
Specific communications with ICRAF and IITA about possible locations and existing research plots. The research proposal will be adapted to the available sites and the proposal finalized. Acquire all necessary equipment and supplies.	August 1 - August 31, 1993
Leave for research location and initiate project.	September 1 - October 31, 1993
Conduct planned research on location through two rainy seasons.	November 1, 1993 - September 24, 1994

Research Sites: Not yet determined.

Budget (93-94): TAMU-05-C

Object	CRSP	External	Matching	Host[a]	Total
Salaries	14,427.13	0.00	6,413.00		20,840.13
Fringe benefits	4,839.11	0.00	1,809.00		6,648.11
Allowances	0.00	0.00			0.00
Consulting	0.00	0.00			0.00
Travel, US	667.39	0.00			667.39
Travel, INT	3,834.78	0.00			3,834.78
Supplies	3,251.08	0.00			3,251.08
Equipment[b]	5,000.00	0.00			5,000.00
Communications	287.39	0.00			287.39
Shipping/Freight	1,500.00	0.00			1,500.00
Publications	583.69	0.00			583.69
Other direct costs	0.00	0.00			0.00
Indirect costs	12,637.95	0.00	3,535.46		16,173.41
TOTAL	47,028.52	0.00	11,757.46	0.00	58,785.98

[a]Not yet determined.
[b]Equipment includes a data logger, two storage modules and soil heat plates.

Subproject Number: TAMU-05-D

Title: Integrated Management of Agricultural Watersheds in Niger

Collaborators and Institutions:

M. Gandah - INRAN, Niger
I. Zanguina - INRAN, Niger
I. Mahaman - INRAN, Niger
A. Manu - TAES, Texas A&M University
T.L. Thurow - TAES, Texas A&M University
A.S.R. Juo - TAES, Texas A&M University
M. Saadou - University of Niamey, Niger
L. Wilding - TAES, Texas A&M University
L. Hossner - TAES, Texas A&M University

I. Zanguina is responsible for the measurement of hydrologic and erosion characteristics of the watershed. M. Saddou provides technical backstopping related to the assessment of the vegetative resources. M. Gandah provides technical backstopping related to crop water use. L. Wildiing provides technical backstopping related to soil resources. L. Hossner provides technical backstopping related to crop growth and yield variability. A. Manu and T.L. Thurow are the lead investigators.

Objectives:

1. Carry out research and demonstration trials in appropriate technologies for sustained crop/fodder production, soil/water conservation and natural vegetation management; and
2. Assess the social, economic and cultural impact of introduced technology.

Progress Report:

Vegetation Reestablishment: During the summer of 1992, microcatchments were installed in four replicated blocks each of degraded thicket ring zones and bare corridors. Selected microcatchments were planted to two woody species (*Prosopis africans* and *Acaia holo*). Sixty plants of each species were planted in each of the three selected blocks. Plant establishment and growth are evaluated monthly. Contour dikes "syrup pan design" for water harvesting also were constructed to connect the two extremes of a recently degraded thicket. Diguettes constructed on the eroded Tondo Kakasia (backslope) are being employed as a demonstration activity. They will be stabilized using *Andropogon guyanus* grass species, which farmers can harvest for seco production in two years.

On-farm Agronomic Research: Farmer- and researcher-managed trials were installed in the arable lands to demonstrate the effect of improved soil and crop management practices on millet and cowpea intercrop systems. The following six treatments are being implemented: (1) traditional cultural practices; (2) chemical fertilization with traditional plant spacing (3) chemical fertilization with recommended plant spacing; (4)

millet cowpea rotation with P fertilization; (5) manure application with recommended plant spacing; and (6) crop residue application with recommended plant spacing. The influence of appropriate technologies management under identical soil and climatic conditions as those experienced by farmers was evaluated through researcher-managed trials that were under the complete surveillance and management of a research team.

Watershed Hydrology and Erosion Studies: Two locations have been equipped with three USLE plots each as follows: (1) on backslope locations; and (2) in the valley on a field planted with millet. Runoff is collected at the bottom of each runoff plot. A flow splitter (1/20) installed at the bottom of each plot is provided to apportion the runoff. Retained runoff from each plot is stored in a 55 gallon drum. Water and sediment samples obtained from each storm are being collected to allow quantification of the sediment and runoff losses. Three tipping bucket rain gages (located on the plateau, backslope and valley) have been set up to record five-minute rainfall intensities and depths. Rainfall intensities, runoff and soil erosion are recorded during the rainy season. During the spring of 1993, a detailed study of the infiltration rates on the various land surfaces within the watershed was conducted using a sprinkler infiltrometer.

Natural Fallow Regeneration Study: In 1989, two 30m x 30m exclosures were installed on fields that had been under continuous cultivation for over five years to demonstrate the effects of improved fallow management on fallow length and quality. After three years in protected fallow, no significant changes in soil acidity were noted when compared to adjacent plots under continuous cultivation for the same period of time. Additional results of this study can be found in the SM-CRSP Annual Report.

Refereed Papers Published:

Geiger, S.C., A. Manu, and A. Bationo, Changes in a sandy Sahelian soil following crop residue and fertilizer additions, *Soil Sci. Soc. Am. J.* 56 (1992):172-177.

Special and Miscellaneous Reports Published:

Sivakumar, M.V.K., A. Manu, S.M. Virmani, and E.T. Kanemasu, Relation between climate and soil productivity in the tropics, *in*: Myths and Science of Soils of the Tropics, Soil Sci. Soc. Am. Special Publ. No. 29, SSSA, Madison, WI, 1992.

Work Planned for Next Year:

Watershed Hydrology and Erosion Studies: Data required to assess runoff and sediment loss characteristics of the watershed will be collected for the entire rainy season (May through September 1993 and 1994) on the USLE plots installed on the eroded sideslope and on the valley walls. Rainfall characteristics including intensities and amounts will be obtained from tipping bucket rain gages and runoff will be collected in the 55 gallon drums. Routine analysis will be carried out on water and sediment samples obtained from each storm to quantify nutrient losses as a function of rainfall, sediment loss and position in the watershed.

On-Farm Agronomic Research: The same sixteen farmer collaborators cultivating on the four soil types will be used to conduct on farm demonstration trials. Funding is requested to complete the study for the current growing season (through December 1993). Farmers will be furnished seed, fertilizer and insecticides an any other purchased inputs required by each treatment. They will, however, be responsible for the day-to-day management of crops from planting to harvest. The following treatments will be implemented on 20m x 25m plots:

- Traditional cultural practice.
- Traditional spacing with chemical fertilization.
- Increased density for both millet and cowpea with chemical fertilization.
- Millet-Cowpea rotation.
- Increased density with farmyard manure.
- Increased density with millet residue as a surface mulch.

Trials entirely managed by the research team will be established on plots adjacent to farmer fields. Funding is requested to complete the study for the current growing season (through December 1993). One each of such trials will be installed on three of the four soil types. These trials will act as barometers for evaluating the abilities of farmers to assimilate and adapt improved technologies. Treatments will include:

- Control, high density without any external inputs.
- High density with chemical fertilization.
- Millet-Cowpea rotation.
- Farmyard manure.
- Millet residue.

Sequential sampling of plots during the entire season will permit evaluation of nutrient dynamics under the different management systems. Weekly monitoring of soil moisture during the season will permit assessment of water use efficiency.

Natural Fallow Study: Chemical and physical transformations in soil resulting from four years of fallow will be assessed on the relevant plots. Funding is requested to complete the study for the current growing season (through December 1993). Their effects on millet and cowpea yields will also be investigated. These results will be compared to those for lands that have been continuously farmed outside the exclosures and the fallow plots farmed during the previous year. Specific parameters to be evaluated will include millet and cowpea yields, infiltration rates and soil fertility indicators including total N, available P, pH and exchangeable bases.

Research Site: Hamdallaye, Niger

Budget (93-94): TAMU-05-D

Object	CRSP	External[a]	Matching	Host[b]	Total
Salaries	20,623.92	13,300.00	5,730.00		39,653.92
Fringe benefits	5,666.99	4,256.00	1,616.00		11,538.99
Allowances	0.00	0.00			0.00
Consulting	0.00	7,760.00			7,760.00
Travel, US	553.37	0.00			553.37
Travel, INT	2,706.75	3,500.00			6,206.75
Supplies	1,230.06	11,500.00			12,730.06
Equipment	0.00	0.00			0.00
Communications	253.37	3,000.00			3,253.37
Shipping/Freight	0.00	3,000.00			3,000.00
Publications	476.69	0.00			476.69
Other direct costs	0.00	0.00			0.00
Indirect costs	10,504.59	0.00	3,158.78		13,663.37
TOTAL	42,015.74	46,316.00	10,504.78	0.00	98,836.52

[a]External contributions are those of USAID/Niger.
[b]Contributions from INRAN (Niger) has not been determined.

SOIL MANAGEMENT CRSP
ANNUAL ACTIVITY WORK PLAN AND BUDGET REQUEST

Fiscal Year: 1993-1994

Project Number: CU-01

Title: Light, Water and Nutrient Dynamics in Agroforestry Systems.

Global Thrust: Natural Resource Management, Sustainable Agriculture

Constraints Addressed: Production-demand pressures, climatic variability, water stress and nutrient losses.

Collaborators and Institutions:
Dr. Susan J. Riha - Assoc. Prof., Cornell University
Dr. Chin Ong - International Center for Research in Agroforestry (ICRAF)

Objectives: Although total world grain production has increased at a rate of approximately 3% per year for the last three decades and average yield per unit land area has doubled (USDA 1988), there is heightened concern that the techniques used to achieve these increases cannot be applied to many parts of the developing world. This is because much of the natural resource base available to poorer farmers has severe agronomic limitations and because few of the external resources necessary to increase productivity are available to them (Kidd and Pimentel, 1992). This has logically led to the desire to identify, understand and develop agricultural systems that can achieve a modest, sustained level of productivity given limited natural and man-made resources. The urgency of this quest has increased because in many areas of the developing world, the most widespread traditional "low-input" agriculture system, forest fallowing, is breaking down because of population and other pressures and leading to accelerated degradation of the natural resource base.

Within this context, agricultural systems can be considered in terms of their abilities to utilize both spatially and temporally as fully and efficiently as possible available light, water and nutrients. Enhanced utilization of these critical resources might be achieved through the use of single, multiple, relay and intercropping systems. Of course, agroforestry systems are of particular interest where specific tree products are desired by farmers. From a systems context, however, they may also be of interest where greater exploitation of the vertical dimension of space (both above and below ground) is feasible and where the short- and/or long-term dynamics of their growth may impart certain advantages for the growth of crops and the maintenance of the resource base (Cannell, 1991).

The manner in which trees may be used more fully to utilize and protect the resource base will differ depending on the agroecological zone of interest. In the humid tropics, the more complete and efficient use of the vertical dimension of space (including multiple storied canopies and deep-rooted species) is considered of interest (Cannell 1991). Although it is often assumed that agroforestry systems will be

productive because of enhanced interception of light in multiple-storied canopies as well as the ability of deep-rooted trees to intercept water and nutrients, there is little evidence to date to support these assumptions (Squire, 1990, Ong, 1991). Additionally, the responses of understory crops in agroforestry systems should be considered in terms of quantifiable alterations in microclimate and soil environments rather than only in qualitative association with a particular tree crop. Without such research, it will be difficult to evaluate the long-term potential of agroforestry systems and to extrapolate research results from one location to another. The objective of this research, therefore, is to contribute both to the immediate development of small farmer cropping systems and to the building of a quantitative understanding of the light, water and nutrient dynamics in agroforestry systems.

Progress Report: The major goal of this past year's activity has been to contact potential collaborators and identify experimental sites for conducting agroforestry research in Africa. If possible, a joint program was to be established with IRA (Cameroon), IITA and ICRAF at the IITA sub-station in Cameroon. Several Cornell faculty both within and outside the Soil Management CRSP have expressed interest in developing a collaborative research program in Cameroon. Professor Randy Barker, Agricultural Economics (and Chairman of the Board of IITA), assumed leadership of the group, and two agricultural economics graduate students were funded by CIIFAD (Cornell International Institute for Food, Agriculture and Development) to spend several months in Cameroon collecting data and exploring opportunities for collaboration. Unfortunately, the political instability in Cameroon left IRA nonfunctional for much of this past year. Additionally, the IITA sub-station in Cameroon apparently has experienced some delays in becoming fully operational. These factors, combined with continued uncertainty about future stability of the Camaroon government and lack of response from the AID mission until late spring (because of a changeover in personnel) led to pursuit of other opportunities. Possibilities for collaborating with ICRAF researchers in other programs in Africa were explored. A positive response was obtained from Dr. Chin Ong at the ICRAF station in Machakos, Kenya. The objectives of the program he directs are very similar to those outlined for this project. Pursuing collaborating with Dr. Ong's program at ICRAF is seen as a good opportunity to further the objectives of this project and at the same time strengthen ties between the Soil Management CRSP and ICRAF.

Manuscripts Published:

McIntyre, Beverly D., David J. Flower and Susan J. Riha, Temperature and soil water status effects on radiation use and growth of pearl millet in a semi-arid environment, *Ag. and Forest Meteorology*, in press.

D.L. Osmond, D.J. Lathwell and S.J. Riha, Prediction of long-term fertilizer requirements of Maise in the tropics using a nitrogen balance model, *Plant and Soil* **143** (1992):61-70.

Plan of Work for Next Year: Collaborative research on resource use in agroforestry systems will be conducted at ICRAF's station in Machakos, Kenya. In particular, we want to test hypotheses concerning the influence of crops on the deep rooting of trees

and whether there is any advantage in combining trees and crops on shallow soils. The specific system we would be working with would likely be *Cassia spectabilis* grown with maize and cowpea in rotation. As outlined by Dr. Ong, the main treatments in the experimental design consist of two soil depths (2 and 0.4 m) and two canopy densities (single branch and ten branches per tree). The trees in this experiment are only 18 months old and though early effects have been noticed, the effects as the trees age are considered most important. Areas of particular interest are partitioning soil water loss among trees, crops and soil evaporation. Also, the extent of water stress experienced by the crops should be measured. In addition to conducting field research, we will utilize and adapt some existing tree growth models in order to interpret and extend the results of these experiments to other climates and soil types.

To accomplish this work in a timely fashion, a research associate from Cornell would be sent to Machakos for a 9 to 12 month period beginning in August 1993. This person would be responsible for collaboratin in the field research and assisting with model development. This phase of the work should be completed by August 1994.

During this period, the senior scientist from Cornell will also pursue collaborations with other Soil Management CRSP scientists in the area of utilizing natural resource information for planning and management of forestry and agroforestry systems.

References:

Cannell, M.G.R., Plant management in agroforestry, *in*: M.E. Avery, M.G.R. Cannell and C.K. Ong (eds.), Biophysical Research for Asian Agroforestry, USA: Winrock International (1991), pp. 59-72.

Kidd, C.V. and D. Pimentel, Integrated Resource Management: Agroforestry for Development, San Diego, CA: Academic Press (1992), 223 pp.

Ong, C.K., Interactions of light, water, and nutrients in agroforestry systems, *in*: M.E. Avery, M.G.R. Cannell and C.K. Ong (eds.), Biophysical Research for Asian Agroforestry, USA: Winrock International (1991), pp. 107-124.

Squire, G.R., The Physiology of Tropical Crop Production, Oxford, UK: C-A-B International (1990), 236 pp.

USDA, Economic Research Service, World Grain 1950-1987, Washington DC: U.S. Government Printing Office (1988).

BUDGET (93-94): CU-01

OBJECT	TOTAL FUNDING SOURCE CRSP	EXTERNAL	MATCHING HOST	TOTAL
Salaries				
Post Doctoral Assoc.				0
-3 mos. on-campus	6,250			6,250
-9 mos. off-campus	18,750			18,750
S. Riha (25%)			15,000	15,000
Administrative Support	500			500
Fringe Benefits @28.97%	7,387			7,387
Matching F.B. @ 36.78%			5,517	5,517
Allowances (GRA & PI)*	12,000			12,000
Visiting Scientist				
Consulting				
Travel				
US				
INT	10,000			10,000
Supplies	1,000			1,000
Communications	2,000			2,000
Analytical Costs				
Publication	1,000			1,000
Labor (off-campus)*				0
TOTAL DIRECT COSTS	58,887		20,517	79,404
Indirect Costs				
On-Campus	20,478		10,874	31,352
Off-Campus (* = Off-Campus)	3,600			3,600
TOTAL PROJECT COSTS	82,965		31,391	114,356

INSTITUTION	FULL TIME EQUIVALENTS (FTE) SCIENTIST SENIOR	JUNIOR	TECHNICIAN	ADM. SUPPORT	OTHER	TOTAL
US	1.25			0.04		1.29
Host	0.05					0.05
Other						0.00
TOTAL	1.30	0.00	0.00	0.04		1.34

Date Initiated:

Expected Completion: August 20, 1995

SOIL MANAGEMENT CRSP
ANNUAL ACTIVITY WORK PLAN AND BUDGET REQUEST

Fiscal Year: 1993-1994

Project Number: NCSU 2

Title: Soil Characterization and Interpretation for Natural Resource Management in the Humid Tropics

Global Thrust: Natural Resource Management

Constraints Addressed: This project addresses portions of three major constraints to better management of the world's soil resources. As science develops better genetic varieties with increased nutrient uptake potential, what is the absolute mineral nutrient reserve content of major soil types in the tropics? Most modern soil characterization procedures rely on "available" or "exchangeable" types of analyses to determine the characteristics of the soil. Few total composition data are available for major soils in the world.

How extreme can leaching losses be in the upland soils? The extreme end of leaching potential through well-drained upland soils in perudic soil moisture regimes have seldom been studied. By characterization of perudic soil moisture regimes in Bolivia, in concert with agronomic research, a better evaluation of leaching and translocation of plant nutrients will be obtained.

How to better apply appropriate technology to site specific soil related problems? A systematic reporting of responses to agronomic practices, as related to quantified soil conditions, is possible through the use of the Fertility Capability Classification system. This is an ongoing activity and electronic storage of the data with geographic display potential will be developed to aid in distributing these data to extension workers, researchers, and decision makers.

Principal Investigators and Institutions:

S.W. Buol - NCSU

Collaborators and Institutions:

Hari Eswaran, USDA/SCS - GIS capability
Jose Salinas, IBTA/Bolivia - Advisor
Jot Smyth, NCSU - Administrative Advisor
Steve Monteith, NCSU - Graduate Student, Bolivia work
John Schmidt, NCSU - Graduate Student, elemental analysis work
Mike Beck, NCSU - Graduate Student, P solubilization work

Objectives:

1. To increase knowledge of soils and soil properties in the humid tropics.
2. To provide soil characterization and classification at agronomic and agroforestry experimental sites used in the other projects.

3. To improve interpretation and extrapolation of research results via Fertility Capability Classification System (FCC) use and expansion.

Progress Report: The majority of the field work has been done in the Chapare of Bolivia. Steve Monteith has intensively sampled on the experiment stations in the area and extensively in areas around the stations. Preliminary laboratory results have determined that extremes in soil reaction and base saturation exist within close spacial proximity. The extremes of base saturation are from less than 10 percent base saturation throughout some profiles to more than 70 percent throughout others. Clay mineral suites in some pedons are rich in mica and 2:1 clays while others are kaolinitic with substantial portions of HIV mineral. Fortunately, the spacial arrangement of soils appears, at this time, to be related to identifiable geomorphic positions and watershed source areas in the mountains. Unfortunately, identification of the geomorphic positions is difficult and cannot be made from remote sensing. Intensive ground truthing appears necessary.

Samples have been obtained from several well identified locations for total elemental characterization. This task is not complete and laboratory analyses are in the preliminary stages.

Several amendments have been made in the format of the interactive computer program of FCC. These formats include the capability to insert pasture and agroforestry recommendations for the FCC units identified. Also, additional condition modifiers for moderately severe phosphate fixing properties have been added to the program. The new drafts of the program have been distributed to users. Their reactions are being considered in evolving drafts.

Work Planned for Next Year: With regard to the Chapare, Bolivia, characterization and total elemental inventory, and intensive laboratory analyses will dominate activities this year. Steve Monteith is scheduled to complete laboratory analyses of the Chapare samples and prepare his Ph.D. dissertation during the year.

John Schmidt is scheduled to complete laboratory analyses of collected samples and, depending upon results encountered, may be able to also complete his dissertation. Should results indicate additional sampling, this may be delayed.

Mike Beck, who has been supported on an AID/Madagascar project, will further test and evaluate the rates of phosphate solubilization from soils of contrasting mineralogical composition. A method of continuous solution flow with resin capture of P has been briefly studied. It is hypothesized that this technique will help predict the expected response of micorrhyzal enhancement of P uptake on different types of soil identified by their mineral compositions. Further laboratory and, perhaps, greenhouse testing is needed to further perfect and evaluate the applicability of this proposed technique.

Research Sites:

Chapare, Bolivia and global humid tropics sampling

Budget:

Total Funding Source, US $1000's

OBJECT	CRSP	EXTERNAL	MATCHING	HOST	TOTAL
Salaries	35.3	3.4	11.9	0.0	50.6
Fringe Benefits	1.8	0.0	2.9	0.0	4.7
Tuition Remission	5.5	0.0	0.0	0.0	5.5
Allowances	0.0	1.2	0.0	0.0	1.2
Consulting	0.0	0.0	0.0	0.0	0.0
Travel, US	1.0	0.0	0.0	0.0	1.0
Travel, Int.	3.0	5.5	0.0	0.0	8.5
Supplies	3.0	2.0	0.0	0.0	5.0
Equipment	0.0	0.0	0.0	0.0	0.0
Communication	3.6	1.0	0.0	0.0	4.6
Shipping/Freight	1.0	2.0	0.0	0.0	3.0
Publication	0.0	0.0	0.0	0.0	0.0
Other Direct Costs	2.0	0.0	0.0	0.0	2.0
Indirect Costs	14.6	3.9	3.9	0.0	22.4
Total	70.8	19.0	18.7	0.0	108.5

Special Budget Requirements:

None

Human Resource Commitments:

Full Time Equivalents (FTE)

	SCIENTISTS					
INSTITUTION	SENIOR	JUNIOR	TECHNICIAN	ADM. SUPPORT	OTHER	TOTAL
US	0.26	2.50	0.14	0.16	0.0	3.06
Host	0.05	0.0	0.0	0.0	0.0	0.05
Other	0.0	0.25	0.0	0.10	0.0	0.35
Total	0.31	2.75	0.14	0.26	0.0	3.46

Narrative explanation of human resources: Mike Beck will return to campus from Madagascar in August, 1993. CRSP stipend support will begin in January, 1994. All other students have completed overseas activities and are based on campus. Most of

the necessary information developed by Bolivian institutes on Chapare soils is available on campus. If needed, Jose Salinas will provide additional information upon request.

Date Initiated: September, 1990

Expected Completion: September, 2000

Signatures:

10 June 93	6-10-93
Principal Investigator Date	Program Coordinator Date
Principal Collaborator Date	Institutional Administrator Date

SOIL MANAGEMENT CRSP
ANNUAL ACTIVITY WORK PLAN AND BUDGET REQUEST

Fiscal Year: 1993-1994

Project Number: TAMU-01

Title: Processes of Soil Degradation and Rejuvenation Under Different Land Use Systems

Global Thrust: Natural Resource Management

Constraints Addressed: Inadequate resource information, landscape restrictions.

Principal Investigators and Institutions:
A.S.R. Juo - TAES, Texas A&M University
L.P. Wilding - TAES, Texas A&M University

Objectives: The principal goals of this project consist of (1) characterization of land degradation processes that alter physico-chemical soil properties in tropical agroecosystems, and (2) development of appropriate and environmentally sound technologies for the rejuvenation of degraded landscapes. Such research would advance the knowledge required for the development of management strategies aimed at the amelioration of degraded soils and the sustainable utilization of vulnerable soils for agricultural production. Presently, this project consists of three subprojects:

TAMU-01-A Structural Changes of Surface Horizons of Vertisols

TAMU-01-B Soil Properties Influencing Hydraulic Sealing of the Surface of Alfisols in the Sahel

TAMU-01-C Soil Degradation and Rejuvenation Processes in Response to Land Use in the Humid Tropics of Zambia

Participating collaborators, specific objectives, progress reports, planned activities and proposed budgets are provided under each subproject.

Budget (93-94): TAMU-01

Object	CRSP	External	Matching	Host	Total
Salaries	31,721.11	0.00	12,987.00		44,708.11
Fringe benefits	10,479.75	0.00	3,664.00		14,143.75
Allowances	0.00	3,000.00			3,000.00
Consulting	0.00	0.00			0.00
Travel, US	1,325.59	0.00			1,325.59
Travel, INT	9,651.19	0.00			9,651.19
Supplies	4,588.39	0.00			4,588.39
Equipment	1,000.00	0.00			1,000.00
Communications	565.59	0.00			565.59
Shipping/Freight	4,000.00	0.00			4,000.00
Publications	1,562.80	0.00			1,562.80
Other direct costs	2,000.00	0.00			2,000.00
Indirect costs	28,334.61	0.00	7,159.93		35,494.54
TOTAL	95,229.03	3,000.00	23,810.93	0.00	122,039.96

Human Resource Commitments:

	Full Time Equivalents (FTE)					
Institution	Senior Scientist	Junior Scientist	Technician	Admin. Support	Other	Total
US	0.31	1.13	0.25	0.25		1.94
Host	0.05					0.05
Other						0.00
Total	0.36	1.13	0.25	0.25	0.00	1.99

Date Initiated: November 1, 1990

Expected Completion: September 24, 1994

Signatures:

Project Leader _____ Date _____

Program Coordinator _____ Date _____

TAMU-01 DESCRIPTION OF SUBPROJECTS

Subproject Number: TAMU-01-A

Title: Structural Changes of Surface Horizons of Vertisols

Collaborators and Institutions:

Clement E. Coulombe - AES, Texas A&M University
Kenneth N. Potter - USDA-ARS, Temple, TX
L.P. Wilding, TAES - Texas A&M University
A.S.R. Juo, TAES - Texas A&M University
R. Loeppert, TAES - Texas A&M University
C. Wendt, TAES - Texas A&M University
Daniel Tessier - INRA, Versailles, France
Ary Bruand - INRA, Orleans, France
A. Seiny-Boukar - IRA, Maroua, Cameroon
Mark A. Bell - CIMMYT, Mexico
Richard Drees - Texas A&M University

Objectives:

1. Compare the effects of native site and one, six and ten years of no-till management and controlled traffic on macroporosity and fabric of surface horizons of Texas Vertisols;
2. Compare the physico-chemical properties of surface horizons of Texas Vertisols under different land use systems: *i.e.*, native, fallow for twenty years, pasture, cereals and row crop;
3. Compare three measurement methods for hydraulic conductivity on Vertisols under different land use systems;
4. Compare the physico-chemical properties of surface horizons of Cameroon Vertisols at different stages of degradation (*i.e.*, native or fallow, non-degraded, mid-degraded and degraded); and
5. Compare three Vertisols in Mexico that exhibit different stages of degradation, expressed by a decrease in yields, even though these Vertisols were submitted to similar land utilization for a period of twenty years.

Progress Report: Samples for micromorphology (objective 1) were collected and have been prepared for image analysis (water replaced with acetone, impregnated with an acetone-polyester resin solution containing a UV dye, coirradiated for polymerization, cut and polished). Samples for routine physico-chemical analysis, bulk density and micromorphology (objective 2) were collected. Determination of total carbon, organic carbon, total nitrogen, pH, EC, CEC and exchangeable cations is completed. Determination of bulk density at field capacity and oven dried, available water and COLE is completed. Samples for micromorphologic analysis have been water replaced with acetone, impregnated with an acetone-polyester resin solution containing a UV dye and Co-irradiated for polymerization. Field measurements (objective 3) of hydraulic

conductivity with three different methods have been completed. Data are in the process of being analyzed.

In October 1992, C. Coulombe traveled to Cameroon to discuss initiation of research on Vertisols in the Maroua area (North Cameroon). The proposed Cameroon study involves a joint collaboration with TAMU,IRA-Cameroon and INRA-France. Several communications over the past year between IRA and TAMU have delineated some of the logistics of the study.

In April 1993, A. Juo, R. Loeppert and C. Wendt traveled to Mexico in response to a request by CIMMYT to discuss solutions to rectify soil-induced productivity problems after long-term cropping on Vertisols. This visit prompted initiation of a study to investigate soil productivity problems at the Tlaltizapan station of CIMMYT. C. Coulombe traveled to Mexico in May to conduct a reconnaissance soil survey at the CIMMYT Tlaltizapan station for site selection. Samples were taken for routine physico-chemical characterization, bulk density and micromorphology. This study is jointly supported by CIMMYT and TropSoils.

Refereed Papers:

Wilding, L.P. and C.E. Coulombe, Expansive soils: Distribution, morphology and genesis, *in*: P. Baveye and M.B. McBride (eds.), Proceedings of the NATO Advanced Research Workshop on Clay Swelling and Expansive Soils, Kluwer Academic Publisher (1993), in press.

Work Planned for Next Year:

CALENDAR OF EVENTS

EVENT	DATE
Analysis of fabric and macroporosity (objectives 1 & 2)	Present - December 1993
Analysis of results of objective 3 and preparation of a paper to ISSS, Acapulco, Mexico (1994)	
Physico-chemical characterization of soil samples and impregnation of micromorphology samples of objective 5	
Hydraulic conductivity measurements of treatments of objective 5.	
Completion of fabric and image analyses of objectives 2 and 5.	
Travel to Cameroon for soil sampling and hydraulic conductivity	January 1994 - May 1994
Fabric and macroporosity analysis of Cameroon Vertisols	June 1994 - September 1994

Research Sites: Temple, Texas, Maroua IRA Research Center, Cameroon, Tlaltizapan, Mexico

Budget (93-94): TAMU-01-A

Object	CRSP	External	Matching	Host[a]	Total
Salaries	14,425.50	0.00	6,643.00		21,068.50
Fringe benefits	4,838.20	0.00	1,874.00		6,712.20
Allowances[b]	0.00	3,000.00			3,000.00
Consulting	0.00	0.00			0.00
Travel, US	667.28	0.00			667.28
Travel, INT	5,834.55	0.00			5,834.55
Supplies	2,250.91	0.00			2,250.91
Equipment	1,000.00	0.00			1,000.00
Communications	267.28	0.00			267.28
Shipping/Freight	2,000.00	0.00			2,000.00
Publications	1,083.64	0.00			1,083.64
Other direct costs[c]	2,000.00	0.00			2,000.00
Indirect costs	14,347.96	0.00	3,662.31		18,010.27
TOTAL	48,715.32	3,000.00	12,179.31	0.00	63,894.63

[a]Not yet determined (Cameroon).
[b]Allowances and per diem for travel to Mexico will be paid by CIMMYT.
[c]Other direct costs ($2,000) are for contractual services to complete laboratory soil analyses.

Subproject Number: TAMU-01-B

Title: Soil Properties Influencing Hydraulic Sealing of the Surface of Alfisols in the Sahel

Collaborators and Institutions:

Justin Heil - TAES, Texas A&M University
A.S.R. Juo - TAES, Texas A&M University
L.P. Wilding - TAES, Texas A&M University
Kevin McInnes - TAES, Texas A&M University
Richard Drees - TAES, Texas A&M University

Objectives:

1. Identify sealing and crusting soils in Alfisols in West Africa and define the degree of sealing or crusting;
2. Determine the soil properties that affect sealing and crusting; and
3. Explain the effect of soil properties on the processes of sealing and crusting in these soils.

Progress Report: Further laboratory work on soils from Hamdallaye, Niger was completed and included the following:

1. Soils crusts were generated using a rainfall simulator. The resulting crusts were prepared for thin section analysis.
2. Infiltration measurements made under simulated rainfall conditons.
3. Modulus of rupture tests performed on prepared soil bricks.

Work Planned for Next Year:

Presentation of defense and completion of dissertation.	Present - December 1993

Research Site: IMAW field site near Hamdallaye, Niger

Budget (93-94): TAMU-01-B

Object	CRSP	External	Matching	Host	Total
Salaries	3,360.14	0.00	996.00		4,356.14
Fringe benefits	1,073.70	0.00	281.00		1,354.70
Allowances	0.00	0.00			0.00
Consulting	0.00	0.00			0.00
Travel, US	24.84	0.00			24.84
Travel, INT	49.67	0.00			49.67
Supplies	137.26	0.00			137.26
Equipment	0.00	0.00			0.00
Communications	44.84	00.0			44.84
Shipping/Freight	0.00	0.00			0.00
Publications	412.42	0.00			412.42
Other direct costs	0.00	0.00			0.00
Indirect costs	2,194.21	0.00	549.11		2,743.32
TOTAL	7,297.08	0.00	1,826.11	0.00	9,123.19

Subproject Number: TAMU-01-C

Title: Soil Degradation and Rejuvenation Processes in Response to Land Use in the Humid tropics of Zambia

Collaborators and Institutions:

Victor Shitumbanuma - Soil Science Dept., University of Zambia (TAMU graduate student).
Lawrence P. Wilding - TAES, Texas A&M University
A.S.R. Juo - TAES, Texas A&M University
Richard Drees - TAES, Texas A&M University

Objectives: Soil degradation is a major concern in Zambia. Soil erosion often has been cited as being the major form of soil degradation; however, other forms of soil degradation occur in varying degrees in different regions of the country. In spite of wide documentation of the problem, not much research has been done to determine the cause and extent of these soil degradation problems. Most of the existing literature on soil degradation in Zambia merely reports existence of the problem. The most comprehensive study on soil degradation in Zambia recently was conducted in the eastern province under the direction of the Ministry of Agriculture. Results from this study describe the nature of the deterioration that has occurred and also the changes that occur when the land is left fallow for several years. However, because of the methods employed in the study, the causes of the observed soil deterioration were difficult to determine.

The purpose of this proposed study is to investigate the processes involved in soil degradation and rejuvenation in response to several land uses in Zambia. The objectives of this study are to:

1. Determine the nature and extent of changes occurring in the physical, chemical and biological soil properties under different kinds of land use;
2. Compare the degree of change of the selected soil properties under different land use types with those under virgin land and/or fallow;
3. Identify the processes involved in the degradation of soils and in the recovery or rejuvenation of degraded soils; and
4. Suggest possible management strategies to reduce the rate of soil degradation and/or rejuvenate degraded soils.

Progress Report: Communication between the University of Zambia, Lusaka and TropSoils/TAMU was initiated in 1992 regarding a mutual interest in starting a collaborative project involving soil degradation and rejuvenation in Zambia.The correspondence was followed by an initial proposal (February 10, 1993), which currently is being refined.

Work Planned for Next Year:

CALENDAR OF EVENTS

EVENT	Date
Elaboration of research plan in collaboration with collaborators (V. Shitumbanuma)	September - April 1994
Begin research in Zambia	June - September 1994

Research Sites: Kasama District, Zambia

Budget (93-94): TAMU-01-C

Object	CRSP	External	Matching	Host[a]	Total
Salaries	13,935.48	0.00	5,348.00		19,283.48
Fringe benefits	4,567.85	0.00	1,509.00		6,076.85
Allowances	0.00	0.00			0.00
Consulting	0.00	0.00			0.00
Travel, US	633.48	0.00			633.48
Travel, INT	3,766.96	0.00			3,766.96
Supplies	2,200.22	0.00			2,200.22
Equipment	0.00	0.00			0.00
Communications	253.48	0.00			253.48
Shipping/Freight	2,000.00	0.00			2,000.00
Publications	66.74	0.00			66.74
Other direct costs	0.00	0.00			0.00
Indirect costs	11,792.42	0.00	2,948.51		14,740.93
TOTAL	39,216.63	0.00	9,805.51	0.00	49,022.14

[a]Contributions from collaborators in Zambia have yet to be determined.

SOIL MANAGEMENT CRSP
ANNUAL ACTIVITY WORK PLAN AND BUDGET REQUEST

Fiscal Year: 1993-1994

Project Number: TAMU-04

Title: Land Resources Characterization and Evaluation in the Semiarid Tropics

Global Thrust: Natural Resource Management

Constraints Addressed: Inadequate resource information, landscape restrictions.

Principal Investigators and Institutions:
L.P. Wilding - TAES, Texas A&M University
A.D.R. Juo · TAES, Texas A&M University

Objectives: The overall goal of this project is to characterize, quantify and evaluate land resources as baseline data for resource management research and technology transfer. This project presently consists of two subprojects:

TAMU-04-A Peanut CRSP/TropSoils Evaluation of Research Sites for Peanut Breeding Trials in Burkina Faso

TAMU-04-B Land Quality and Restoration of Mined-out Bzuxite Lands in Jamaica

Participating collaborators, specific objectives, progress reports, planned activities and proposed budgets are provided under each subproject.

Budget (93-94): TAMU-04

Object	CRSP	External	Matching	Host	Total
Salaries	15,589.08	12,000.00	9,917.00		37,506.08
Fringe benefits	5,480.18	3,500.00	2,798.00		11,778.18
Allowances	0.00	0.00			0.00
Consulting	0.00	0.00			0.00
Travel, US	747.52	0.00			747.52
Travel, INT	2,495.05	3,000.00			5,495.05
Supplies	4,421.28	0.00			4,421.28
Equipment	0.00	0.00			0.00
Communications	747.52	0.00			747.52
Shipping/Freight	1,500.00	0.00			1,500.00
Publications	123.76	0.00			123.76
Other direct costs	19,750.00	4,000.00			23,750.00
Indirect costs	21,867.40	1,400.00	5,467.45		28,734.85
TOTAL	72,721.79	23,900.00	18,182.45	0.00	114,804.24

Human Resource Commitments:

	Full Time Equivalents (FTE)					
Institution	Senior Scientist	Junior Scientist	Technician	Admin. Support	Other	Total
US	0.46	0.50		0.24		1.20
Host	0.05					0.05
Other	0.15	0.50				0.65
Total	0.66	1.00	0.00	0.24	0.00	1.90

Date Initiated: November 1, 1990

Expected Completion: September 24, 1994

Signatures:

Project Leader _____ Date _____ Program Coordinator _____ Date _____

TAMU-04 DESCRIPTION OF SUBPROJECTS

Subproject Number: TAMU-04-A

Title: Peanut CRSP/TropSoils Evaluation of Research Sites for Peanut Breeding Trials in Burkina Faso.

Collaborators and Institutions:

L.P. Wilding -AES, Texas A&M University
Philippe Sankara - University of Ouagadougou, Burkina Faso
O.D. Smith, TAES - Texas A&M University
L.R. Hossner, TAES - Texas A&M University
A.S.R. Juo, TAES - Texas A&M University
Proper Zambre - University of Ouadadougou, Burkina Faso
A.M. Schubert - TAES, Texas A&M University (Peanut CRSP)
A. Manu - TropSoils, Texas A&M University

Objectives:

1. Characterize the morphological, physical, chemical and mineralogical properties responsible for site variability of six Peanut CRSP research sites in Burkina Faso—Tenkodago, Gampela, Kombissiri, Saria, Bobo Dioulasso and Niangoloko, Burkina Faso;
2. Establish field plot uniformity at the above sites;
3. Identify soil-based crop constraints associated with these sites; and
4. Establish a long-term (five-year) "Soil Amendments for Peanut Production on Acid Soils of Burkina Faso" sustainable agriculture project in Bob Dioulasso, Burkina Faso.

Progress Report:

Site Characterization: Routine physical and chemical properties and selected mineralogical properties have been analyzed for six pedons (four Alfisols and two Ultisols) collected on Peanut CRSP research sites. Alfisols (Kanhaplustalfs) have developed from the granitic bedrock complex and transported sediments derived therefrom. They are more productive, have nigher weatherable mineral reserves, have higher base status, lack exchangeable Al, and exhibit fewer physical and chemical constraints than Ultisol (Kanhaplustult) counterparts associated with polycycled sandstone alluvium and colluvium.

Soils associated with the granitic bedrock in eastern Burkina Faso (Tenkodogo, Kombissiri, Gampela and Saria) are similar in texture, pH base status, cation sorption capacity, drainage, and mineral reserve. They differ primarily in soil depth in the following order: Gampela > Tenkodogo > Kombissiri > Saria. The first two are greater than 2 m, whereas Saria is less than 1 m in depth. This could be an important factor affecting available soil water content during soil moisture stress periods. From a peanut crop productivity viewpoint, I estimate that Gampela would be greatest and

Saria lowest. These soils are Kanhaplic Haplustalfs, reflecting well drained, high base status, kaolinitic-rich, low-activity clay systems.

Soils associated with sandstone colluvium or alluvium (multiple weathered and transported sediments) of western Burkina Faso (Bobo-Dioulasso and Niangoloko) are deep, very acid, low base, low to moderately high exchangeable Al saturation, sands over clayey subsoil systems that contain few weatherable minerals. Major constraints are low nutrient availability (especially N,P,K) and Al toxicity. These soils are Ultisols rather than Alfisols (Arenic and Typic Kanhaplustults), reflecting their well drained, highly weathered, low base status and low activity clay (kaolinite) systems. Both sites are nutrient impoverished and would respond to management practices or amendments that increase nutrient supply and organic matter.

Soil variability in Peanut CRSP research plots likely is caused by differences in drainage relating to horizon depth and thickness, depth to granitic bedrock and depth to root restrictive layers.

Soil Amendments for Peanut Production on Acid Soil of Burkina Faso: Mature peanut seed yields were increased for two of three genotypes by application of ash in southwest Burkina Faso. No significant yield responses were obtained from the application of phosphorus or gypsum. Foliar and soil test results are available for the 1992 crop season; however, they have not yet been analyzed.

Work Planned for Next Year:

Soil Characterization and Site Evaluation: During the fall of 1993, research will continue to complete laboratory analyses of physical properties (bulk density, water retention and thin-section porosity), selected mineralogy assays (clay, sand and silt) and total elemental analyses (Ca, K, Fe) of soils sampled in 1989 and 1993. This will allow more definitive statements on physical constraints of these sites to complement established chemical constraints.

Long-term Fertility Amendment Trial for Sustainable Agriculture: Soil and foliar analyses of samples collected in 1992 will be studied and interpreted. The potential peanut response to K in this soil will be investigated by applying K, as KCl, to half plots of the ash $CaSO_4$ and P_2O_5 treatments. The plots of these treatments would receive the normal amount of ash, gypsum or phosphorus fertilizer on the whole plot. Peanut yield, soil and plant parameters will be analyzed for concentrations of the essential nutrients and will continue to be monitored in 1994.

Research Sites: Gampela, Burkina Faso, Bobo Dioulasso, Burkina Faso, Tenkodogo, Burkina Faso, Kombissiri, Burkina Faso, Saira, Burkina Faso, Niangoloko, Burkina Faso.

Budget (93-94): TAMU-04-A

Object	CRSP	External	Matching	Host	Total
Salaries	712.90	0.00	1,970.00		2,682.90
Fringe benefits	393.32	0.00	556.00		949.32
Allowances	0.00	0.00			0.00
Consulting	0.00	0.00			0.00
Travel, US	49.17	0.00			49.17
Travel, INT	98.33	0.00			98.33
Supplies	573.75	0.00			573.75
Equipment	0.00	0.00			0.00
Communications	249.17	0.00			249.17
Shipping/Freight	0.00	0.00			0.00
Publications	24.58	0.00			24.58
Other direct costs[a]	8,000.00	0.00			8,000.00
Indirect costs	4,343.52	0.00	1,086.18		5,429.70
TOTAL	14,444.74	0.00	3,612.18	0.00	18,056.92

[a]Other direct costs include (1) analysis of spatial soil and plant variability on long-term fertilizer plot ($4,500) and (2) completion of bulk density, water retention and mineralogy on six Burkina Faso pedons at target research sites ($3,500).

Subproject Number: TAMU-04-B

Title: Land Quality and Restoration of Mined-out Bauxite Lands in Jamaica

Collaborators and Institutions:

L.P. Wilding - TAES, Texas A&M University
M.A. Hussey - TAES, Texas A&M University
W. Greenberg - TAES, Texas A&M University
H. Lambert - TAES, Texas A&M University
G. Wilson - Jamaica Agricultural Research Programme, Jamaican Agricultural Development Foundation, Kingston, Jamaica
A. Mangaroo - Prairie View A&M University
Sylvan McDaniel - ALCAN, Jamaica

Dr. M.A. Hussey provides technical backstopping related to crop and forage studies. Dr. A. Mangaroo provides technical backstopping related to crop studies. Ms. Wendy Greenberg is a graduate student at Texas A&M University conducting research related to the characterization of soils and determination of productivity constraints on bauxite-mined lands in Jamaica. Mr. Hugh Lambert is a Jamaican graduate student at Texas A&M University conducting research related to crop and forage studies on mined-out lands in Jamaica. Mr. Sylvan McDaniel is the Company Manager of ALCAN Land Reclamation Programs in Jamaica and provides assistance with access, equipment, labor and background information on research sites. Dr. George Wilson is the director of the Jamaica Agricultural Research Programme of JADF and provides in-country support to collaborators.

Objectives:

1. Conduct a feasibility assessment of restored bauxite mined lands with initial characterization of soils to:

    - determine the quality and range in characteristics;
    - define the short interval spatial variability;
    - compare sites restored in different time periods;
    - compare with natural pre-mined soil; and
    - determine the usability and recommendations for small farming.

2. Evaluate botanical composition and biomass productivity of restored bauxite-mined lands as correlated with their physical and chemical properties and fertility parameters; and
3. Determine productivity constraints of crops and soil conserving grasses and shrubs on representative restored bauxite mined lands.

Progress Report: In September 1992, a team of TropSoils soil scientists consisting of L.P Wilding and L.R. Hossner travelled to Jamaica to initiate the project. They had discussions with JARP, ALCAN, the Jamaica Bauxite Institute, CEATA, and USAID personnel. They also visited some restored mine sites in the Mandeville area and took a few preliminary soil samples. In October 1992, Hugh Lambert travelled to Jamaica to collect information on aerial photographs, topographic maps and soil information available for the Mandeville area.

Wendy Greenberg travelled to Jamaica January 10 to February 6, 1993 to begin soil evaluations. During that period she accomplished the following:

- Identified potential research plot areas in restored mine pits of three different age classes.
- Conducted 29 depth transects in six mine pits.
- Completed a description of restored mine soils and a native soil from five soil pits and 18 auger holes; soil and plant samples were taken and sent to TAMU.
- Held discussions with ALCAN employees regarding methods of reclamation and restoration of bauxite mine pits.

The samples collected during this trip were analyzed at Texas A&M University laboratories for physical and chemical properties and nutrient composition. A. Mangaroo and M.A. Hussey also travelled to Jamaica in January 1993. This trip provided background information on reclamation procedures being used by ALCAN, and insight into the spatial variability of reclaimed sites as well as the long-term objectives of ALCAN and the Jamaican Government regarding the return of mined lands to small farmers.

Dr. L.P. Wilding, Dr. M.A. Hussey, Wendy Greenberg and Hugh Lambert travelled to Jamaica in May 1993 to set up vegetation plots. These plots were established in an attempt to find an indicator crop for soil variability. Hugh Lambert is scheduled to remain in Jamaica through August to plant and monitor the plots. Ms. Greenberg will return to Jamaica in August to work with Hugh Lambert in delineating areas of crop response variation.

Work Planned for Next Year: During the fall of 1993, Ms. Greenberg will analyze and evaluate data from soil depth transects, lab data on physical and chemical properties, and crop response variation on the summer's vegetation plots. In late fall 1993 or early spring 1994 Ms. Greenberg will go to Jamaica for four to six weeks to determine the soil variability as related to the crop variability. This will allow an evaluation of which soil properties in the mined lands are most limiting to crops. In addition to digging soil pits, non-invasive methods for soil physical property evaluation will be tested. These methods may include Electromagnetic Induction and Ground Penetrating Radar. In the spring and summer of 1994, Ms. Greenberg will conduct further laboratory analyses to evaluate physical properties of soil samples brought back in February 1993. This work will establish potential constraints of restored lands relative to a reference unmined site.

Mr. Hugh Lambert will spend the summers of 1993 and 1994 in Jamaica. Each year he will establish two field experiments. Experiment I will be coordinated with an

extensive soil survey to be conducted by Ms. Greenberg, and Experiment II will evaluate several tropical legumes for adaptation.

Experiment I: This research will be conducted in collaboration with ALCAN (Mr. Sylvan McDaniel) and JARP (Dr. George Wilson). Daily assistance will come primarily from Mr. McDaniel and ALCAN. Strip plots consisting of corn, peanuts and pigeon pea will be established during May and used as bioassays for soil chemical and physical limitations to crop production. A minimum of five strips will be established on three reclaimed and one native site.

Estimates of crop biomass will be made along line transects at all sites. Paired estimates of plant and soil mineral concentration will be obtained in areas showing normal and depressed plant growth. These data will be used as background information to establish field plots in 1994 where specific nutrients and/or water harvesting techniques will be used in an attempt to enhance crop production. Detailed soil characterization will be made in areas with depressed plant growth.

Experiment II: The objectives of this study will be to evaluate several tropical legumes for their adaptation, persistence and seasonal nutrient composition. The legumes will be planted in August 1993. Long-term plans will attempt to use the best adapted legumes in cropping systems to enhance soil fertility and as a supplemental feed for small ruminants.

Research Sites: Research will be conducted primarily in areas around Mandeville, Jamaica that have been mined over the last thirty years by ALCAN. Research also may be conducted on some of the ALCAN mined areas around Ewarton, Jamaica.

Budget (93-94): TAMU-04-B

Object	CRSP	External[a]	Matching	Host	Total
Salaries	14,876.18	12,000.00	7,947.00		34,823.18
Fringe benefits	5,086.86	3,500.00	2,242.00		10,828.86
Allowances	0.00	0.00			0.00
Consulting	0.00	0.00			0.00
Travel, US	698.36	0.00			698.36
Travel, INT	2,396.71	3,000.00			5,396.71
Supplies	3,847.54	0.00			3,847.54
Equipment	0.00	0.00			0.00
Communications	498.36	0.00			498.36
Shipping/Freight	1,500.00	0.00			1,500.00
Publications	99.18	0.00			99.18
Other direct costs[b]	11,750.00	4,000.00			15,750.00
Indirect costs	17,523.86	1,400.00	4,381.27		23,305.13
TOTAL	58,277.05	23,900.00	14,570.27	0.00	96,747.32

[a]External contributions shown are those of (1) JARP/JADF—$15,500 for Mr. Lambert's graduate assistantship, $3,000 for Mr. Lambert's travel to Jamaica and per diem of U.S. collaborators in Jamaica, and (2) under other direct costs—$4,000 for estimated labor and equipment costs provided by ALCAN.

[b]Other indirect costs include (1) characterization of soil samples ($7,500) and (2) rental of ground-penetrating radar and electromagnetic induction and other non-invasive equipment to measure spatial variability of depth to bedrock ($4,250).

SOIL MANAGEMENT CRSP
ANNUAL ACTIVITY WORK PLAN AND BUDGET REQUEST

Fiscal Year: 1993-1994

Project Number: CU-05

Title: Land Evaluation as a Tool for Sustained Rural Development

Global Thrust: Natural Resource Management

Constraints Addressed: Agricultural development research in many West African countries is fragmented. Soil scientists collect soil data but are not involved in crop performance; social scientists and farming system specialists describe production systems but not soils and have no yield data. Soil fertility research seldom has precise information on kinds of soils. Economic interpretations are seldom made.

The project will integrate the approaches listed above into a computerized expert system shell to produce guidelines and recommendations for better land use alternatives that are environmentally and economically sustainable.

Principal Investigators and Institutions:

A. Van Wambeke - Professor of Soil Science, College of Agriculture and Life Sciences at Cornell University

Dr. Ayuk Takem - Minister of Scientific Research, Yaounde, Cameroon

Dr. S.S. Jagtap - Agroclimatologist, IITA, Ibadan, Nigeria

Collaborators and Institutions: Cooperative programs are being developed or will be initiated in three West African countries. The most advanced negotiations are with Cameroon in cooperation with IITA. Other institutions in Burkina Faso have been contacted during a visit to Ouagadougou. Several individuals from African countries, including Niger, who attended an ALES training workshop held in Dschang (Cameroon) and Ouagadougou (Burkina Faso), expressed interest in collaboration. Morocco is also being considered for extending the project (in cooperation with TSMM).

Cameroon. The following collaborators and institutions have agreed to cooperate with the research. The study area selected is the central province of Cameroon. Mr. S. Numbem Tchatchoua will be based either at the IRA (Institut de la Recherche Agronomique) station of Nkolbisson or the IITA Humid Tropic Station in Mbalmayo. Field work is presently scheduled to start early in 1994.

The following individuals have been contacted: Dr. G. Gillman, IITA Soil Scientist in Nkolbisson, Dr. E. Attayi, IITA representative in Cameroon, and Dr. Baker, Agricultural Economist IITA/NCRE in Nkolbisson.

Burkina Faso. During a June 15-25, 1992 trip to Ouagadougou, the following institutions expressed interest in cooperating in the development of the ALES expert system software. They are:

- Bureau National des Sols (Bunasol), Drs. N. Sourabie and F. Pallo.
- Institut de Developpement Rural (University of Ouagadougou), Dr. P. Sankara who cooperates with the Peanut CRSP and Dr. L. Wilding (Texas A&M) on soil characterization.
- Recherches sur les Systemes de Production (INERA-CNRST), Dr. D. Kabore and Mr. Youl Sansan (ESFIMA).

Activities in Burkina Faso are being coordinated with TSMM Economic Research Service (ERS-USDA), more specifically with Dr. J. Day.

Niger. Contacts with institutions in Niger have only been by correspondence. The Institut National de la Recherche Agronomique du Niger (INRAN), a TropSoils institution cooperating with Texas A&M, has purchased the software and is a potential cooperator. The individual correspondents are Mr. Oumarou Idrissa and Moussa Oumarou.

The economic and political situation in some African countries is such that there are uncertainties regarding host country support for collaborative research. The nature of this project allows flexibility in timing, location and selection of collaborating institutions; the budget section of this progress report is structured so it can adapt to fluctuating political situations.

Objectives: The project is designed to give West African countries a tool with which to build expert systems that integrate all data important in decisions regarding optimum, sustainable land use. This would help alleviate the present damaging abuse of soil resources. Land utilization types to be included will be food crops, rotations, and tree crops under different levels of management thus taking advantage of existing knowledge and actual research on agronomic practices now being carried out in West Africa.

There also is a need to increase the effectiveness of the ALES software. This can only be done in cooperation with the three groups of scientists mentioned before: soil resource inventory people, agronomists and agricultural economists. There will be constant feedback to include new experiences in the expert system shell. The way to achieve our purposes is to involve scientists in interdisciplinary projects that link their specialties into one major thrust, which will result in expert systems that can advise farmers or other decision makers how to select the most profitable land-use alternatives for specific land types and, conversely, how to select the best land for a given land use. The knowledge base would include criteria regarding the preservation of natural resources.

The goal is to create a system that can provide services to rural, city or regional planning agencies. Extension agents would also be a target audience. The project contains a training component of nationals who would be responsible for the maintenance and updating of the system after the project is completed. The activities proposed in this project can be extended to almost all West-African countries.

Progress Report: Mr. S. Numbem Tchatchoua has continued his training by taking courses selected on the basis of the intended research. They include database management and geographical information systems in the soil inventory aspects of the research. Agricultural economics courses included were Price Analysis, Land Economic Problems and Microeconomic Issues. In the City and Regional Planning Department, Mr. Numbem took courses titled Computers in Planning, Project Planning and Planning Analysis.

During a June 1992 visit to Cameroon, a tentative study area for Mr. Numbem's research was selected. The Central Province, with a base at Nkolbisson and/or Mbalmayo, would be the focus area making use of a social science database, soil resource information and economic analysis data provided by IITA and IRA/NCRE.

The social science database is being analyzed. As far as we can tell, it does not contain soil information. A small-scale soil map of the Central Province borrowed from the University of Ghent is being digitized to serve as a base map for planning the research. Preliminary consultations with IITA and the Institut de la Recherche Agronomique (IRA) have been initiated.

A French ALES manual and a French software version have been completed and are presently available for distribution.

A trip to Burkina Faso together with TSMM was planned but could not be made because of lack of clearance by the USAID mission in Ouagadougou.

Work Planned for Next Year: The workplan has two components: (1) a focused area mode that involves Cornell University graduate students working in collaboration with LDC researchers in developing countries, and (2) a software training course mode and a follow-up of trainees through correspondence and consulting. The first component includes:

Cameroon. Mr. Numbem will continue his course work at Cornell and expectes to complete it at the end of 1993. He will then travel to Cameroon to start two years of field research. His activities in Cameroon essentially will consist of collecting soil information in farmers' fields where yield data and input-output data are available in a number of villages included in the IITA social science survey.

IRA at Nkolbisson, IITA Humid Tropic Station at Mbalmayo, NCRE economic analysis unit will be among the host country collaborators. The principal investigator will travel to Cameroon to set up the detailed workplan and coordinate it with IITA and local research interests. The research would involve identification and selection of a number of cropping or farming systems and would include a detailed description of their edaphic, agronomic, economic and social components.

Burkina Faso. The principal investigator will travel to Burkina Faso to coordinate a workplan with the three Burkinabe institutions mentioned above. The progress made by them in the use of the ALES software will be evaluated. At present the activity is contingent on a research project being planned by TSMM and the signature of a Memorandum of Agreement by the TropSoils Management Entity. Coordination with the soil resource inventory work at Texas A&M also will be sought. Concurrence of the USAID mission may be a decisive factor.

Niger. Travel to Ouagadougou will be extended to include a visit to INRAN to evaluate progress made in use of the ALES software.

The second component of the proposed workplan is contingent on requests from LDC Universities or other educational institutions to provide teaching staff in computerized land evaluation during one-week training sessions. A model budget request for such events is given in the "special budget requirement" section of this report. It is based on previous sessions organized in Dschang (Cameroon), Piracicaba (Brazil) and Manila (Philippines). At present the following institutions have requested detailed information on the organization of such training workshops: the "Escuela Agricola Panamericana" in Zamorano (Honduras), the "Instituto Geografico Agustin Codazzi" in Colombia, and the University of Chiang Mai in Thailand.

Research Sites: Three countries were mentioned in the previous section as possibilities for land evaluation research. Only in Cameroon are activities sufficiently advanced to be specific enough to select the Central Province as a concentration area. Morocco is a possible country in which to initiate similar activities in Africa.

Budget (93-94): CU-05

Object	CRSP	External	Matching	Host	Total
Salaries					
GRA[a], stipend	13,439	8,000			13,439
GRA, fees	4,690				4,690
Van Wambeke			$12,530		12,530
Administrative	500				500
Fringe benefits					
@ 28.97%	145				145
@ 36.78%			4,609		4,609
Allowances (PI)	8,000				8,000
Travel					
US	1,200				1,200
International	14,000				14,000
Supplies	3,000				3,000
Equipment	1,500				1,500
Maintenance	500				500
Communications	1,500				1,500
Shipping/Freight	750				750
Other direct costs	3,000				3,000
Indirect costs					
on campus (@53%)	19,878		9,084		28,962
off campus(@24%)	2,047				2,047
TOTALS	74,149	8,000	26,223		108,372

[a]The graduate student lineup includes two individuals: Mr. S. Numbem T., who will start his field work in January 1994 in Cameroon and will receive support from his fellowship with IITA, and a graduate student who will start his course work in the spring semester of 1994 (and is tentatively assigned to Burkina Faso).

Special Budget Requirements:

Cameroon: At the time of preparation of the above, budget contacts were being made with IITA and IRA to obtain accurate information on host and external contributions during the field work in Cameroon. Special budget requirements may be necessary for field vehicles in Cameroon to reach the research sites. Costs may include either rental of a vehicle and/or supplies such as gasoline, etc. or the purchase of a vehicle. It is not possible at present to predict local transportation needs accurately because the precise locations of the research sites have not yet been determined.

Training Courses: A model budget for TropSoils' contributions to land evaluation training sessions is given below. It is based on figures used for the June 1992 training session in Manila:

Object	CRSP	External	Matching	Host	Total
Travel					
International					
Instructor	3,000				3,000
Collaborator	3,000				3,000
National (host)	1,000				1,000
Supplies	3,000			1,000	4,000
Allowances	2,000			1,000	3,000
Communications	500			250	750
Indirect Costs on campus(@53%)	6,625				
TOTALS	19,125			2,250	21,375

Human Resource Commitments:

	Full Time Equivalents					
	Scientists					
Institution	Senior	Junior	Technician	Adm.Support	Other	Total
US	15%					
Host		100%				
Other						

Narrative explanation of human resources: The table above reflects the present status of the Principal Investigator's understanding of the commitments made by participating institutions that indicated their willingness to contribute to the field work in Cameroon. It is the intent of the Principal Investigator to clarify these matters before sending Mr. S. Numbem Tchatchoua to Cameroon. At the time of this progress report, discussions were underway.

It is anticipated that human resources contributions are forthcoming from staff at IITA and IRA in Nkolbisson and Mbalmayo. Given the interest they expressed in this kind of research, prospects are excellent.

Date initiated: September 25, 1991

Expected Completion: September 24, 1996

Global Thrust 2. Sustainable Agriculture

SOIL MANAGEMENT CRSP
ANNUAL ACTIVITY WORK PLAN AND BUDGET REQUEST

Fiscal Year: 1993-1994

Project Number: NCSU 3

Title: Sustainable Soil Management Alternatives to Slash and Burn

Global Thrust: Sustainable Agriculture

Constraints Addressed: Soil acidity, nutrient deficiency and losses, soil physical limitations, and water stress

Principal Investigators and Institutions:
M.G. Wagger and T.J. Smyth - NCSU

Collaborators and Institutions:
P. Luna - NCSU graduate student conducting dissertation research
J. Alegre - ICRAF, Peru
K. Cassel - NCSU

Objectives:
1. Determine the factors responsible for sustainable production in principal crop and pasture-based soil management options for the humid tropics.
2. Determine the lower threshold values below which the aforementioned management options are environmentally or economically impractical.

Progress Report: Project support to field work in Yurimaguas on mechanized continuous cultivation and legume-based pastures was terminated in 1991/1992. Keith Cassel and Julio Alegre are finalizing two Soil Management CRSP bulletins on information compiled in this project on management of physical properties.

Pedro Luna has completed the field component of his research in Chapare, Bolivia on effects legume cover crop management during 12 to 18 month fallows on subsequent rice and cowpea crops in two separate farmer fields. Pedro returned to campus in March, 1993 and is completing analysis of soil and plant samples collected during the third and final crop in the experiments. There are no additional field activities in this project.

Work Planed for Next Year: Laboratory analyses will continue for several months and should be completed by mid Fall, 1993. The majority of time in the coming year, however, will be devoted to Pedro Luna writing his Ph.D. dissertation. This project will terminate upon anticipated completion of his dissertation in July, 1994.

Research Sites:
Chapare, Bolivia

Budget:

Total Funding Source, US $1000's

OBJECT	CRSP	EXTERNAL	MATCHING	HOST	TOTAL
Salaries	17.0	0.0	6.2	0.0	23.2
Fringe Benefits	1.8	0.0	1.5	0.0	3.3
Tuition Remission	5.5	0.0	0.0	0.0	5.5
Allowances	0.0	0.0	0.0	0.0	0.0
Consulting	0.0	0.0	0.0	0.0	0.0
Travel, US	1.0	0.0	0.0	0.0	1.0
Travel, Int.	0.0	0.0	0.0	0.0	0.0
Supplies	1.0	0.0	0.0	0.0	1.0
Equipment	0.0	0.0	0.0	0.0	0.0
Communication	3.6	0.0	0.0	0.0	3.6
Shipping/Freight	0.0	0.0	0.0	0.0	0.0
Publication	0.0	0.0	0.0	0.0	0.0
Other Direct Costs	1.0	0.0	0.0	0.0	1.0
Indirect Costs	8.0	0.0	2.0	0.0	10.0
Total	38.8	0.0	9.7	0.0	48.5

Special Budget Requirements: None

Human Resource Commitments:

Full Time Equivalents (FTE)

	SCIENTISTS					
INSTITUTION	SENIOR	JUNIOR	TECHNICIAN	ADM. SUPPORT	OTHER	TOTAL
US	0.12	0.83	0.14	0.16	0.0	1.25
Host	0.0	0.0	0.0	0.0	0.0	0.0
Other	0.0	0.0	0.0	0.0	0.0	0.0
Total	0.12	0.83	0.14	0.16	0.0	1.25

Narrative explanation of human resources: With the termination of overseas field activities there are no contributions from host institutions to this project.

Date Initiated: September 1, 1972

Expected Completion: September 30, 1994

Signatures:

Michael G. Wagner 6/11/93 — Principal Investigator Date

6-10-93 — Program Coordinator Date

Principal Collaborator Date

Institutional Administrator Date

SOIL MANAGEMENT CRSP
ANNUAL ACTIVITY WORK PLAN AND BUDGET REQUEST

Fiscal Year: 1993-1994

Project Number: NCSU 4

Title: Agroforestry Systems for Acid Soils of the Humid Tropics

Global Thrust: Sustainable Agriculture Production

Constraints Addressed: Soil acidity, nutrient depletion and losses, topographic limitations, water stress, and weeds

Principal Investigators and Institutions:

C.B. Davey - NCSU

Collaborators and Institutions:

P.O. Ruiz - NCSU graduate student conducting dissertation research at Yurimaguas

C.A. Palm - TSBF, Nairobi providing technical supervision during periodic visits to Yurimaguas

J.C. Alegre - ICRAF, Peru representative provide on-site coordination and supervision

A. Salazar - NCSU graduate student and former agroforestry specialist for INIAA, Yurimaguas

I. Castilla - INIAA chemist and laboratory administrator

E. Fernandes - NCSU faculty posted in Manaus

Objectives:

The overall objective is to reduce fertilizer and herbicide input requirements for maintaining system sustainability through improved nutrient cycling and soil surface protection by the inclusion of trees. Specific objectives addressed in ongoing research are:

1. To evaluate the influence of VA mycorrhizal roots on the success of various agroforestry species,
2. Quantify and compare mycorrhizal infection among different soil management systems, and
3. Measure the dynamics of soil P among different agroforestry systems by modifications of the Hedley fractionation method.

Progress Report: Various soil management systems at Yurimaguas, Peru affected the abundance and diversity of VA mycorrhizae. Plants in the high and low input continuous cropping systems had the lowest infection. Infection in a peach palm plantation was intermediate. Four genera of VAM fungi dominated all plants, but their abundance varied with soil management system.

Results show that soil management influences the dominance of VAM fungi populations through changes in soil chemical properties and/or plant population diversity. Implications relate to nutrient uptake by crop plants, especially P, and to nutrient dynamics in the soil. These results reveal a highly significant effect of the VAM fungi on the management of the tree component of agroforestry systems. These fungi are a natural and abundant resource which, when managed properly, can assist in the sustainability of agroforestry systems at little or no cost.

The following publication was produced on VAM fungi by Pedro Ruiz:

Ruiz, P.O. 1992. Significado de las micorrizas para la agroforestería en Ultisoles de la Amazonia. Suelos Amazonicos, No. 4, 31 pgs. (INIAA, Proyecto Suelos Tropicales, Lima, Peru).

Work Planned for Next Year: Phosphorus cycling between plants and soil is complex and involves both organic and inorganic forms. Availability of P in Ultisols appears to be affected by organic forms and fixed mineral P. A soil P fractionation procedure (M. Beck modification of the Hedley procedure) will be used to describe the dynamics of soil P in a secondary forest, a high input cropping system, a low input cropping system, and an agroforestry system.

The research will be conducted from January to August, 1993 at Yurimaguas, Peru, by host country collaborators and NCSU graduate student, Pedro Ruiz. Experiments will be installed, measured, and harvested. Soil and tissue samples will be collected and analyses started. Pedro Ruiz will return to NCSU in August 1993 and will complete laboratory research in December 1993. In 1994, Pedro Ruiz will finalize data analysis with anticipated completion of his Ph.D. dissertation in September.

Research Sites:

Yurimaguas, Peru and Raleigh, NC

Budget:

Total Funding Source, US $1000's

OBJECT	CRSP	EXTERNAL	MATCHING	HOST	TOTAL
Salaries	18.8	0.0	7.3	0.0	26.1
Fringe Benefits	1.8	0.0	1.7	0.0	3.5
Tuition Remission	5.5	0.0	0.0	0.0	5.5
Allowances	0.0	0.0	0.0	0.0	0.0
Consulting	0.0	0.0	0.0	0.0	0.0
Travel, US	1.0	0.0	0.0	0.0	1.0
Travel, Int.	3.0	0.0	0.0	0.0	3.0
Supplies	1.2	0.0	0.0	0.0	1.2
Equipment	0.0	0.0	0.0	0.0	0.0
Communication	3.6	0.0	0.0	0.0	3.6
Shipping/Freight	0.0	0.0	0.0	0.0	0.0
Publication	0.0	0.0	0.0	0.0	0.0
Other Direct Costs	1.2	0.0	0.0	0.0	1.2
Indirect Costs	9.4	0.0	2.4	0.0	11.8
Total	45.4	0.0	11.4	0.0	56.8

Special Budget Requirements: None

Human Resource Commitments:

Full Time Equivalents (FTE)

	SCIENTISTS					
INSTITUTION	SENIOR	JUNIOR	TECHNICIAN	ADM. SUPPORT	OTHER	TOTAL
US	0.27	1.00	0.14	0.16	0.0	1.57
Host	0.0	0.0	0.0	0.0	0.0	0.0
Other	0.0	0.0	0.0	0.0	0.0	0.0
Total	0.27	1.00	0.14	0.16	0.0	1.57

Narrative explanation of human resources: Since travel to Yurimaguas is not permitted, participation by the P.I. on field activities is by extensive communication through FAX, e-mail and mail. Julio Alegre provides on-site supervision and coordination of field activities.

With Pedro's return to NCSU, the P.I. will be directly and fully involved with activities next year.

Date Initiated: September 1981

Expected Completion: September 1994

Signatures:

C. A. Davey TJS 6-10-93
Principal Investigator Date

6-10-93
Program Coordinator Date

Principal Collaborator Date

Institutional Administrator Date

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To Roger Hanson	From Jot Smyth
Co.	Co.
Dept.	Phone #
Fax #	Fax #

Dr. Joth Smyth
Soil Science Department
Tropsoil Coordinator
Raleigh NC

June 13 1993

Dear Jot

I accept to support the continuation of the Comparative dynamics experiment (Y-412) because was planned as a long term study (20-25 years) and untill now we are getting very good results with some of the treatments which can be transfered to other parts of the world.

It is very important to receive external funding for the continuation of this experiment due to limited funds of the National Institutions.

For this experiment we need around 40,000 US Dollars for a year and the funds which will be used in direct support of this study during the comming year can be as fallow:

ICRAF	PL-480	INIA	NSF	NC
11,400	10,000	5,000	3,000	10,600

Thank you for your interest in support this study.

Sincerely

Dr. Julio Alegre
Jefe Programa Agroforestal
Yurimaguas Perú

BEST AVAILABLE DOCUMENT

SOIL MANAGEMENT CRSP
ANNUAL ACTIVITY WORK PLAN AND BUDGET REQUEST

Fiscal Year: 1993-1994

Project Number: UH-03

Title: Developing Aluminum and Reducing P Fixation in Variable-Charge Soils with Organic Amendments

Global Thrust: Sustainable Agriculture

Constraints Addressed: Soil acidity.

Acid soils, characterized by low pH, excessive Al, and often deficient in Ca and P, make up a major portion of soils in the humid tropics. Consequently, crop production in these soils has been adversely affected. Conventional amendments to soil acidity, using commercial $CaCO_3$ and synthetic P fertilizers, may not be effective, available to, or affordable by subsistence farmers of many developing countries. To address this constraint, our research, along with that of many others on soil organic amendments, has shown that (1) additions of green manures or animal wastes reduce, or even eliminate, Al toxicity, (2) surface application of organically complexed Ca can increase Ca availability and decrease Al toxicity in the acid subsoils, and (3) organic amendments increase P availability. Given these positive preliminary results, the use of organic materials (green manures, composts, Ca-fulvates) to correct soil acidity—at the plow layer and in the subsoil—warrants detailed investigations.

Principal Investigator and Institution:
Nguyen Hue - Project Leader, University of Hawaii

Collaborator and Institution:
Xuexin Huang - PR China, University of Hawaii

Objectives:

1. *Rules on Liming with Organic Materials:* Liming values of a cowpea green manure (*Vigna unguiculata*) and a residential sewage sludge were evaluated on an Al-toxic Ultisol, a Mn-toxic Oxisol, and a mixture (1:1 by weight) of the two soils. Unamended pH values were 4.5 to 4.8, amendment rates were 0, 5, and 10 g/kg, and the test crop was soybeans (*Glycine max*) grown in 2-kg pots in the greenhouse. Results showed that (1) manure additions reduced Al toxicity but increased Mn toxicity, and (2) the higher the application rate the stronger the effect. It appeared that these two seemingly contradictory effects were caused by the same mechanism: complexation of Al and Mn by organic molecules derived from the manures. Why organically chelated Mn is phytotoxic but organically chelated Al is not remains an unanswered question that warrants further research.

2. *Residual Liming Effects of Organic Amendments:* Persistence of the liming effectiveness of four organic residues was determined in a greenhouse experiment that lasted over 18 months. Two strongly acid soils (Hawaiian Ultisols having 7.1 and 3.6 $cmol_c$ Al kg^{-1} as extracted with KCl) were incubated with four levels of $CaCO_3$ at 0, ½, 1, and 2 times the extractable Al or with cowpea leaf, leucaena leaf, chicken manure, or sewage sludge at 20 g kg^{-1}. The treated soils were subjected to numerous wetting/drying cycles; and the incubation periods were 1, 6, 12, and 18 months. *Sesbania cochinchinensis* and *Desmodium intortum* (tropical forage legumes sensitive to Al) were grown as test crops. The results indicated that plants grown on the unamended soils always had the lowest dry matter yield and Ca concentration and the highest Al concentration. Soil data further confirmed that improved growth resulted from increased Ca and decreased Al brought about by either $CaCO_3$ or organic manure additions. Plots of relative yield vs. plant Al showed that 10% and 50% reductions in growth of *Sesbania* occurred when plant Al $\geq$ 45 and 83 mg kg^{-1}, respectively. In general, both $CaCO_3$ and organic manure treatments reduced plant Al concentrations for all four incubation periods, suggesting that the Al-detoxifying effects of the manures could last more than 1½ years after application.

Progress Report: Last year's work concentrated mainly on the enhancement effect of organic amendments on P solubility and availability.

Synthetic goethite was prepared and mineralogically and chemically characterized. Maximum P sorption on goethite was determined to be approximately 18,000 mg P/kg at pH 6.5 and ionic strength of 0.03 *M*. Goethite is a dominant mineral in highly weathered soils; thus its high P sorption may explain the high P fixing property of many highly weathered tropical soils. On the other hand, more than double the amount of P was desorbed from goethite into solution in the presence of 5 m*M* malate, a naturally occurring organic anion, than in its absence.

Effects of organic amendments on P sorption (an indirect indication of P solubility and availability) were subsequently studied on an Oxisol (Wahiawa Series) and an Ultisol (Paaloa Series), using chicken manure, cowpea green manure, and Kailua (anaerobically digested) sewage sludge. The organic materials were thoroughly mixed with the soils at 0, 2.5, 5, and 10 g/kg, and equilibrated at field water holding capacity for 4 weeks before sorption experiments began. Organic amendments, even at the lowest rate of 2.5 g/kg, decreased P sorption significantly and increased soil pH moderately. As an illustration, 430 mg P/kg must be sorbed on the unamended Oxisol to maintain 0.20 mg P/L in solution; this quantity was reduced to 360, 350, and 370 mg P/kg in the presence of 2.5 g/kg of chicken manure, cowpea leaf, and sewage sludge, respectively.

The increased availability of P brought about by organic amendments was further studied in the greenhouse, using guava seedlings and soybeans as test crops grown on an acid Ultisol. Plant height, dry matter weight, and tissue P concentration were significantly increased with increasing rates of rock P (0, 150, and 300 mg P/kg as Florida rock P) and with increasing rates of cowpea green manure (0, 5, and 10 g/kg). Detailed analyses are in progress, and an M.S. thesis is being prepared.

Thesis completed:

Vega, Silvio, "Charge characteristics, cation composition, and effects of organic amendments on highly weathered soils at different pH levels," M.S. thesis, University of Hawaii (1993), 152 pp.

Work Planned for Next Year:

Problem Statement and Justification: Subsoil acidity is a serious constraint to crop production in the humid tropics (Cahn *et al.*, 1993). Toxic levels of soluble and/or exchangeable Al and low levels of Ca severely impair plant-root development in these problem soils (Farina and Channon, 1988). Excess Al causes stunted, coralloid root systems because of disruption of mitosis in the root tips, which disrups—if not destroys—the roots' uptake function. Consequently, water and, to a lesser extent, nutrients that may be abundant in the subsoil become inaccessible to the plants.

Vertical movement of surface-applied $CaCO_3$ (agricultural lime) is extremely slow, probably because lime-released OH^- anions are consumed by the soil acidity, leaving Ca^{2+} cations unaccompanied. These Ca^{2+} ions often are adsorbed by exchange sites on the soil surface. [Electrical neutrality principle dictates that Ca^{2+} movement must be accompanied by equivalent anions.] Thus, surface incorporation of $CaCO_3$ or $Ca(OH)_2$ has little effect on subsoil Al and/or Ca (Mathews and Joost, 1990). Deep incorporation of lime by physical means is costly and often undesirable because infertile subsoil is exposed. Recently, gypsum and phosphogypsum have been proposed as effective amendments to subsoil acidity (Farina and Channon, 1988; Alva *et al.*, 1990). The mode of action of gypsum in reducing subsoil Al toxicity is still open to debate. Nevertheless, proposed mechanisms include (1) greater solubility of $CaSO_4$ which produces more SO_4^{2-} which, in turn, exchanges for OH^- on Al and Fe hydrous oxide surfaces (Rajan, 1978; Parfitt and Smart, 1978), (2) the formation of aluminum-hydroxy-sulfate minerals (Hue *et al.*, 1985; Wolt *et al.*, 1992), and/or (3) decreased activity of Al^{3+} brought about by ion pair formation and increased concentration of the less-toxic $AlSO_4^+$ ions. If these mechanisms are operating with SO_4^{2-}, it is logical to predict that they would work equally well or even better with organic material-derived anions in correcting subsoil acidity. Research has shown that Al can be rendered nonphytotoxic by simple organic anions such as citrate and malate (Hue *et al.*, 1986), and that incorporation of green manures or sewage sludge can reduce/eliminate Al toxicity (Hue and Amien, 1989; Hue, 1992). Recently, van der Watt *et al.* (1991) compared the soil amendment effects of a coal-derived Ca-fulvate with gypsum, $CaCO_3$, and $Ca(OH)_2$. They concluded that Ca-fulvate was most effective in moving Ca down the soil profile and in increasing subsoil pH. These lines of evidence lead us to hypothesize that Ca-fulvates (extracted from common organic wastes), when surface applied, can serve as an effective liming agent for acid subsoils.

Objective: Compare several Ca-fulvates with $CaCO_3$ and $CaSO_4$, all surface applied, in terms of increasing Ca and reducing Al levels in deeper horizons of acid soils. This will be acomplished through the following approach:

1. **Preparation of Ca-fulvates:** Saturated $Ca(OH)_2$ solutions will be used to extract fulvates and humates from common organic wastes such as sewage sludge, chicken manure and cowpea green manure. HCl will be used to precipitate the humic acids (pH will be adjusted to 2.0). Solution pH will again be raised to 7.0 with $Ca(OH)_2$. Free Ca^{2+} and Cl^- will be washed off by either dialysis (using dialysis membrane with molecular weight cut-off ≈ 500-1000) or mixed- resin exchanger. The remaining solutions would contain high proportion of Ca-fulvates. Ca, Cl, and soluble C will be determined from these solutions.
2. **Leaching Columns:** Several 1-m long PVC columns will be prepared and packed with at least 60-cm material of an acid subsoil. Treatments containing equivalent amounts of Ca from Ca-fulvates, $CaCO_3$, $CaSO_4$, and $CaCl_2$ will be applied to the column tops. Deionized water equivalent to ≈ 100-200 cm rainfall will be applied slowly over a 2-week period to the columns.
3. **Monitoring Parameters:** Leachate will be collected periodically and analyzed for Ca, Al, soluble C, pH, and EC. Columns will be dismantled, and soils will be sectioned by 5-cm increments and analyzed for pH, Ca, Al, and organic carbon.
4. **Field Survey:** If time and resources allow, on-going field experiments with organic amendments will be sampled down to 1m depth to monitor the movement of Ca, Al, and soluble organic C.

References:

Alva, A.K., M.E. Sumner, and W.P. Miller, Reactions of gypsum or phoshogypsum in highly weathered acid subsoils, *Soil Sci. Soc. Am. J.*, 54 (1990):993-998.

Cahn, M.D., D.R. Bouldin, and M.S. Cravo, Amelioration of subsoil acidity in an Oxisol of the humid tropics, *Biol. Fertil. Soils*, 15 (1993):153-159.

Farina, M.P.W. and P. Channon, Acid-subsoil amelioration: II. Gypsum effects on growth and subsoil chemical properties, *Soil Sci. Soc. Am. J.*, 52 (1988):175-180.

Hue, N.V., Correcting soil acidity of a highly weathered Ultisol with chicken manure and sewage sludge, *Commun. Soil Sci. Plant Anal.*, 23 (1992):241-264.

Hue, N.V. and I. Amien, Aluminum detoxification with green manures, *Commun. Soil Sci. Plant Anal.*, 20 (1989):1499-1511.

Hue, N.V., G.R. Craddock and F. Adams, Effect of organic acids on aluminum toxicity in subsoils, *Soil Sci. Soc. Am. J.*, 50 (1986):28-34.

Hue, N.V., F. Adams and C.E. Evans, Sulfate retention by an acid BE horizon of an Ultisol, *Soil Sci. Soc. Am. J.*, 49 (1985):1196-1200.

Mathews, B.W. and R.E. Joost, The effects of leaching surface-applied amendments on subsoil aluminum and alfalfa growth in a Louisiana Ultisol, *Commun. Soil Sci. Plant Anal.*, 21 (1990):567-581.

Parfitt, R.L. and R.S. Smart, The mechanism of sulfate adsorption on Fe oxides, *Soil Sci. Soc. Am. J.*, 42 (1978):48-50.

Rajan, S.S.S., Sulfate adsorbed on hydrous alumina, ligands displaced, and changes in surface charge, *Soil Sci. Soc. Am. J.*, 42 (1978):39-44.

van der Watt, H.V.H., R.O. Barnard, I.J. Cronje, J. Dekker, G.J.B. Croft and M.M. van der Walt, Amelioration of subsoil acidity by application of a coal-derived calcium fulvate to the soil surface, *Nature*, 350 (1991):146-148.

Wolt, J.D., N.V. Hue and R.L. Fox, Solution sulfate chemistry in three sulfur-retentive Hydrandepts, *Soil Sci. Soc. Am. J.*, 56:(1992)89-95.

Research Sites: University of Hawaii

Budget (93-94): UH-03

Object	CRSP	Total Funding Source External	Matching	Host	Total
Salaries	14000		4600		18600
Fringe Benefits	1400				1400
Allowances	0				0
Consulting	0				0
Travel, US	1500				1500
Travel, INT	0				0
Supplies	1000				1000
Equipment	0				0
Communications	0				0
Shipping/Freight	0				0
Other	500	0	0	0	500
Direct costs	18400	0	4600		23000
Indirect costs	8096	0	0	0	8096
Total	26496	0	4600	0	31096

Special Budget Requirements: None.

Human Resource Commitments:

Full Time Equivalents (FTE)

INSTITUTION	SCIENTISTS SENIOR	SCIENTISTS JUNIOR	TECH	ADM. SUP.	OTHER	TOTAL
US	.25	.50				.75
Host						
Other						
Total	.25	.50				.75

Narrative Explanation of Human Resources: A graduate research assistant, Mr. Xuexin Huang, is employed by the project to conduct the field research in consultation with Nguyen Hue.

Date Initiated: September 1991

Expected Completion: October 1994

Signatures:

Principal Investigator	Date	Program Coordinator	Date

If signatures are not available, attach a letter or other document that indicates that this project is a cooperative effort.

SOIL MANAGEMENT CRSP
ANNUAL ACTIVITY WORK PLAN AND BUDGET REQUEST

Fiscal Year: 1993-1994

Project Number: NCSU 7

Title: Synchrony Between Soil Nutrient Availability and Plant Nutrient Uptake

Global Thrust: Sustainable agriculture

Constraints Addressed: Nutrient Deficiencies and Losses

Principal Investigators and Institutions:
M.G. Wagger - NCSU

Collaborators and Institutions:
K.M. Glasener, NCSU graduate student conducting dissertation research at field site in Bolivia.
S.R. Funderburk, NCSU graduate student providing corollary support to the resource quality component of this project via work conducted in North Carolina.
R. Mejia, IBTA/Chapare scientist providing technical support for the soil components of the field research.
R. Delgadillo, IBTA/Chapare scientist providing technical support for the cropping system components of the field research.

Objectives:
1. Determine the effects of organic additions with variable polyphenolic, lignin and N contents on N release patterns, soil N dynamics, and soil-crop N budgets.
2. Determine the effects of organic nutrient supply with variable release patterns on crop uptake and yield.

Progress Report: A visit to Bolivia in early March was used to: (1) select a field research site on the La Jota Experiment Station, (2) collect plant and soil samples from the selected site for chemical and physical characterization, (3) collaborate with IBTA/Chapare counterparts on future research activities, and (4) review laboratory procedures and equipment available at the IBTA/San Benito Experiment Station. As a result of this visit, the final development of experimental plans for the field research has been complete. On the basis of this experimental plan, the field component of the research objectives is projected to take approximately two years. Cleaning of the field site, a secondary forest should be completed by July.

It is anticipated that Mr. Karl Glasener will leave for Bolivia in early July to initiate the field research. In preparation for his departure date, the preliminary plan and soil samples have been analyzed and equipment/supplies continue to be purchased for use

in Bolivia. Correspondence with our Bolivian collaborators has also enabled the timely completion of this phase of the project, particularly with regard to site preparation.

On the domestic front, work is underway to develop appropriate methodology for specific phenolic compounds(s) that would serve as the best indicator for legume decomposition.

Work Planned for Next Year: After clearing the secondary forest site, two tropical legumes will be established in early October, 1993. These legumes will be maintained weed/pest free for four to eight months in order to accumulate adequate biomass/nutrients and suppress weeds. At the end of the legume growth period, two experiments will be initiated. The first experiment will employ the N-difference method to assess the effectiveness of N release from the legumes to a subsequent rice-rice-cowpea rotation. There will be two sequences of this rotation (6 crops total) requiring approximately two years to complete. A litter bag decomposition study initiated at the same time will complement the N-difference experiment. The participants during this phase of the research are K. Glasener, R. Mejia, and R. Delgadillo.

As a corollary to this approach and within the same experimental plots, a more detailed N balance study will be conducted utilizing ^{15}N-labeled legume residues in 2x3 m microplots. The ^{15}N-labeling will be accomplished approximately two weeks prior to planting the first rice crop. Both above- and belowground legume components will be monitored for ^{15}N release during the subsequent cropping sequences via plant and soil sampling. Primary responsibility for this study rests with K. Glasener, however, we anticipate involvement with the host country collaborators. The use of ^{15}N methodology should provide them with some hands-on experience heretofore unavailable.

During the four to eight month legume growth period, there will be time to set up analytical procedures at the San Benito laboratory located 40 km outside of Cochabamba. Work will also continue in North Carolina by S. Funderburk on the development of appropriate methodology to characterize specific phenolic compounds.

Research Sites:

IBTA's La Jota Experiment Station in Chapare, Bolivia

Budget:

Total Funding Source, US $1000's

OBJECT	CRSP	EXTERNAL	MATCHING	HOST	TOTAL
Salaries	21.6	9.2	10.5	5.0	46.3
Fringe Benefits	1.8	0.0	2.5	0.0	4.3
Tuition Remission	0.0	0.0	0.0	0.0	0.0
Allowances	8.4	0.0	0.0	0.0	8.4
Consulting	0.0	0.0	0.0	0.0	0.0
Travel, US	1.0	0.0	0.0	0.0	1.0
Travel, Int.	7.0	0.0	0.0	0.0	7.0
Supplies	3.6	2.0	0.0	11.4	17.0
Equipment	2.0	0.0	0.0	1.3	3.3
Communication	3.6	0.0	0.0	0.4	4.0
Shipping/Freight	2.4	0.0	0.0	0.0	2.4
Publication	0.0	0.0	0.0	0.0	0.0
Other Direct Costs	1.2	1.0	0.0	0.0	2.2
Indirect Costs	13.1	0.0	3.4	0.0	16.5
Total	65.6	12.2	16.4	20.1	114.3

Special Budget Requirements:
It is essential that a drying oven be available for preparing plant samples at the La Jota Experiment Station. Because of the frequency of travel from the field research at La Jota to the laboratory at San Benito, an IBTA/Chapare vehicle will be shared with collaborators in project NCSU 1. Vehicle maintenance costs will also be shared with project NCSU 1. In exchange for the vehicle contribution, both NCSU projects will upgrade the San Benito laboratory, which currently specializes in analyses for alkaline and sodic soils, with equipment to perform routine soil and plant analyses for the IBTA/Chapare program. Equipment includes soil stirrers, diluter/dispensers, and a colorimeter.

Human Resource Commitments:
IBTA/Chapare has designated Raul Mejia and Roberto Delgadillo as counterpart scientists for projects NCSU 1 and 7. Although Sharon Funderburk's investigations are supported entirely with domestic project funds, many of the legume materials to be analyzed for polyphenolics came from IBTA/Chapare and CIAT/Santa Cruz (Bolivia). Her investigations, therefore, are directly relevant to project activities at the field site.

Full Time Equivalents (FTE)

INSTITUTION	SCIENTISTS SENIOR	SCIENTISTS JUNIOR	TECHNICIAN	ADM. SUPPORT	OTHER	TOTAL
US	0.19	1.25	0.14	0.16	0.0	1.74
Host	0.25	1.50	1.00	0.50	2.00	5.25
Other	0.0	0.0	0.0	0.0	0.0	0.0
Total	0.44	2.75	1.14	0.66	2.00	6.99

Narrative explanation of human resources:

In addition to counterpart scientist time, IBTA/Chapare will also contribute directly with field labor and laboratory technician support for the project. Karl Glasener will initiate on-site activities in July, 1993.

Date Initiated: April 17, 1991

Expected Completion: December, 1995

Signatures:

Michael G. Hagen 6/11/93 — Principal Investigator Date

T. Q. Smith 6-10-93 — Program Coordinator Date

Principal Collaborator Date

Institutional Administrator Date

DESCRIPCION DEL COMPONENTE

PROGRAMA: AGROFORESTERIA

1. CODIGO Y NOMBRE DEL SUBPROYECTO: SISTEMA AGROFORESTAL (CONV. N.CAROLINA U

2. CODIGO Y NOMBRE DEL COMPONENTE: 01-122-01

Sincronizacion de la disponibilidad de nutrientes demulches y abonos verdes de leguminosas tropicales yutilizacion por cultivos.

3. UNIDAD EJECUTORA: Proyecto IBTA/CHAPARE

4. UBICACION DEL COMPONENTE
ESTACION EXPERIMENTAL LA JOTA

5. DESCRIPCION DEL COMPONENTE:

BEST AVAILABLE DOCUMENT

5.1 JUSTIFICACION

Recientes investigaciones en el uso aplicado de mulches y abonos verdes han demostrado que estas practicas pueden suministrar suficient nitrogeneo y otros nutrientes necesarios para la produccion sostenida de cultivos. Sin embargo, mas investigacion es necesario para el desarrollo de tecnologia concerniente al uso de mulches y abonos verdes para incrementar la produccion en la region de Chapare.

5.2 OBJETIVOS:

- Estudiar los mecanismos de liberacion de nutrientes provenientes de deposiciones organicas relacionadas con sus caracteristicas quimicas.

- Desarrollar la capacidad de predecir la disponibilidad de nutrientes y mejorar la sincronizacion con los cultivos manejando tiempo, cantidad y metodo de aplicacion de los mulches.

5.3 METAS CONTEMPLADAS:

A) METAS GLOBALES

- Proveer a los agricultores del Chapare practicas agricolas basadas en bajos insumos y sostenibles para la produccion de alimentos y mejorar sus condiciones de vida.

B) METAS DE LA GESTION 1993:

- Estudio de invernadero de la tasa de descomposicion de varias leguminosas.

- Implantacion del experimento en campo con 4 leguminosas con diferentes tasas de descomposicion seleccionadas en invernadero.

- Siembra de la rotacion arroz-frijol-yuca con variedades locales.

AÑO INICIO: 1993 AÑO CONCLUSION: 1995

CRONOGRAMA DE ACTIVIDADES

ACTIVIDADES	E	F	M	A	M	J	J	A	S	O	N	D
ESTUDIO DE INVERNADERO												
PREPARACION DE TERRENO												
SIEMBRA DE LEGUMINOSAS												
SIEMBRA DEL CULTIVO Y APLIC. MULCH.												
SIEMBRA: ARROZ-FRIJOL-YUCA												
COSECHA CULTIVO												
MUESTREO DE SUELOS												
MUESTREO DE TEJIDO												

7. BENEFICIARIOS:

3. PRESUPUESTO ANALITICO DEL COMPONENTE:

SAFCO	D E S C R I P C I O N	D E T A L L E	MONTO($US)
120	MANO DE OBRA		5000.00
213	SERVICIOS TELEFONICOS		400.00
233	ALQUILER DE TIERRAS Y TERRENOS		200.00
250	SERVICIOS PROFES. Y COMERCIALE		400.00
311	ALIMENTOS Y BEB. P/PERSONAS		200.00
314	PRODUCTOS AGROFORESTALES		700.00
315	MADERA Y PRODUC. DE MADERA		300.00
341	PAPEL DE ESCRITORIO		300.00
344	LIBROS Y REVISTAS		600.00
361	SUBSTANCIAS QUIMICAS		3300.00
362	COMBUSTIBLES Y LUBRICANTES		1800.00
363	ABONOS Y FERTILIZANTES		600.00
364	INSECT., FUMIGANTES Y OTROS		300.00
374	CEMENTO, CAL Y YESO		400.00
377	PRODUC. DE MAT. PLASTICO		2400.00
381	PRODUC. SIDERURGICOS FERRICOS		400.00
386	HERRAMIENTAS MENORES		200.00
395	UTILES DE ESCRITORIO		200.00
397	UTILES Y MATERIALES ELECTRICOS		400.00
398	OTROS REPUESTOS Y ACCESORIOS		400.00
399	OTROS MATERIALES Y SUMINISTROS		300.00
431	EQUIPO DE OFICINA Y MUEBLES		800.00
432	MAQUINARIA Y EQUIPO DE PRODUC.		500.00
	TOTAL		20100.00

BEST AVAILABLE DOCUMENT

PRESUPUESTO DEL COMPONENTE POR TRIMESTRE, AÑO 1993 (EN $US)

DESCRIPCION	I	II	III	IV	TOTAL
MANO DE OBRA	0.00	1000.00	2000.00	2000.00	5000.00
SERVICIOS TELEFONICOS	0.00	100.00	150.00	150.00	400.00
ALQUILER DE TIERRAS	0.00	200.00	0.00	0.00	200.00
SERVICIIOS PROFESIONALES	0.00	100.00	150.00	150.00	400.00
ALIMENTOS Y BEBIDAS	0.00	50.00	75.00	75.00	200.00
PRODUCTOS AGROF.	0.00	200.00	250.00	250.00	700.00
MADERA Y PRODUCT.	0.00	75.00	150.00	75.00	300.00
PAPEL DE ESCRITORIO	0.00	100.00	100.00	100.00	300.00
LIBROS Y REVISTAS	0.00	100.00	250.00	250.00	600.00
SUBSTANCIAS QUIMICAS	0.00	800.00	1250.00	1250.00	3300.00
COMBUST. Y LUBRIC.	0.00	400.00	700.00	700.00	1800.00
ABONOS Y FERTILIZ.	0.00	200.00	200.00	200.00	600.00
INSECT., FUMIG. Y OTROS	0.00	100.00	100.00	100.00	300.00
CEMENTO, CAL Y YESO	0.00	125.00	150.00	125.00	400.00
PRODUCT. MAT. PLASTICO	0.00	600.00	900.00	900.00	2400.00
PRODUCT. SIDERURGICAS	0.00	100.00	150.00	150.00	400.00
HERRAM. MENORES	0.00	50.00	75.00	75.00	200.00
UTILES DE ESCRITORIO	0.00	50.00	100.00	50.00	200.00
UTILES Y MANT. ELECTRIC.	0.00	100.00	150.00	150.00	400.00
OTROS REPUEST. Y ACCES.	0.00	100.00	150.00	150.00	400.00
OTROS MAT. Y SUMINIST.	0.00	100.00	100.00	100.00	300.00
EQUIPO DE OFICINA Y MUEBLES	0.00	200.00	400.00	200.00	800.00
MAQUIN. Y EQUIPO PRODUC.	0.00	150.00	200.00	150.00	500.00
TOTAL	0.00	5000.00	7750.00	7350.00	20100.00

BEST AVAILABLE DOCUMENT

SOIL MANAGEMENT CRSP
ANNUAL ACTIVITY WORK PLAN AND BUDGET REQUEST

Fiscal Year: 1993-1994

Project Number: TAMU-03

Title: Soil Fertility Management for Sustainable Agriculture

Global Thrust: Sustainable Agriculture

Constraints Addressed: Nutrient deficiencies and losses, soil acidity

Principal Investigators and Institutions:
L.R. Hossner - TAES, Texas A&M University
A.B. Onken - TAES, Texas A&M University

Objectives: The overall goal of this project is to develop sustainable, low-input management strategies that improve and/or maintain soil fertility to permit an increase in total yields and reduce year-to-year and within-farm variability. This project presently consists of three subprojects:

TAMU-03-A	Release of Carbon and Nitrogen During Decomposition of Cowpea Green Manure and Millet Residue
TAMU-03-B	Soil Management CRSP/INTSORMIL Collaborative Research in Mali
TAMU-03-C	Nutrient Deficiency and Toxicity Studies at the Cinzana Station, Mali

Participating collaborators, specific objectives, progress reports, planned activities, and proposed budgets are provided under each subproject.

BEST AVAILABLE DOCUMENT

Budget (93-94): TAMU-03

Object	CRSP	External	Matching	Host	Total
Salaries	21,539.24	3,500.00	8,081.00	10,000.00	43,120.24
Fringe benefits	6,576.82	525.00	2,280.00		9,381.82
Allowances	0.00	0.00			0.00
Consulting	0.00	0.00			0.00
Travel, US	1,709.56	0.00			1,709.60
Travel, INT	5,419.21	5,000.00			10,419.21
Supplies	3,814.40	2,500.00		500.00	6,814.40
Equipment	0.00	4,500.00			4,500.00
Communications	809.60	500.00			1,309.60
Shipping/Freight	0.00	0.00			0.00
Publications	1,604.80	0.00			1,604.80
Other direct costs	1,590.00	1,590.00		750.00	3,930.00
Indirect costs	16,190.95	3,623.00	4,455.23		24,269.18
TOTAL	59,254.62	21,738.00	14,816.23	11,250.00	107,058.85

Human Resource Commitments:

	Full Time Equivalents (FTE)					
Institution	Senior Scientist	Junior Scientist	Technician	Admin. Support	Other	Total
US	0.51	0.63	0.35	0.25	0.10	1.84
Host	0.10	0.20	0.20		0.10	0.60
Other						
Total	0.61	0.83	0.55	0.25	0.20	2.44

Date Initiated: November 1, 1990

Expected Completion: September 24, 1994

Signatures:

Project Leader _____ Date _____

Program Coordinator _____ Date _____

TAMU-03 DESCRIPTION OF SUBPROJECTS

Subproject Number: TAMU-03-A

Title: Release of Carbon and Nitrogen During Decomposition of Cowpea Green Manure and Millet Residue

Collaborators and Institutions:

Kathrin Franzluebbers - TAES, Texas A&M University
Richard Weaver - TAES, Texas A&M University
Anthony Juo - TAES,Texas A&M University
Andrew Manu - TAES, Texas A&M University (Niamey, Niger)
Lloyd Hossner - TAES, Texas A&M University
Thomas W. Boutton - TAES, Texas A&M University

Objective:

1. Characterize carbon and nitrogen mineralization from decomposing cowpea green manure and millet residue in Niger and also under controlled conditions.

Progress Report: A field experiment to study decomposition of cowpea green manure and millet residue was conducted in Niger in 1991 and repeated in 1992. An additional study was conducted in 1992 at Texas A&M University under controlled conditions to study the decomposition of cowpea. Soil and plant sample analyses from field and laboratory experiments were completed. Statistical analyses of results are partially completed. Writing of the dissertation and manuscripts for publication are in progress.

In a field study conducted during the rainy seasons of 1991 and 1992 in Niger, addition of plant material to a sandy Alfisol cropped to millet was made in the form of cowpea green manure and millet residue. The objective of this study was to estimate rates of decomposition of added plant materials by measuring release of carbon as CO_2 and release of inorganic nitrogen. Lab analyses of soil and plant samples were performed at Texas A&M University and at ICRISAT, Niger, during 1991 and 1992. The field experiment was repeated in 1992. Results indicate an increase in millet straw and grain yields due to application of millet or cowpea residue.

Release of carbon and nitrogen from decomposing cowpea plant parts was investigated under both continuously moist and repeatedly dried and wetted conditions at 30°C. Cowpeas had been grown under greenhouse conditions and were separated into leaves, stems, roots and nodules. Each plant part was treated separately and in combination. Chemical and statistical analyses are in progress.

Work Planned for Next Year:

Further statistical analysis of results,
and completion of dissertation
in December, 1993 Present - December 1993

Research Site: N'Dounga, 20 km southeast of Niamey, Niger

Budget (93-94): TAMU-03-A

Object	CRSP	External	Matching	Host	Total
Salaries	3,399.47	0.00	1,104.00		4,503.47
Fringe benefits	1,095.40	0.00	312.00		1,407.40
Allowances	0.00	0.00			0.00
Consulting	0.00	0.00			0.00
Travel, US	527.55	0.00			527.55
Travel, INT	55.10	0.00			55.10
Supplies	41.32	0.00			41.32
Equipment	0.00	0.00			0.00
Communications	27.55	0.00			27.55
Shipping/Freight	0.00	0.00			0.00
Publications	513.77	0.00			513.77
Other direct costs	0.00	0.00			0.00
Indirect costs	2,433.87	0.00	608.88		3,042.75
TOTAL	8,094.03	0.00	2,024.88	0.00	10,118.91

Subproject Number: TAMU-03-B

Title: Soil Management CRSP/INTSORMIL Collaborative Research in Mali

Collaborators and Institutions:

Arthur B. Onken - TAES, Texas A&M University
Aboubacar Toure - Institut d'Economie Rurale, Mali
Samba Traore - Institut d'Economie Rurale, Cinzana Station, Mali
Gary C. Peterson - TAES, Texas A&M University
Mamadou Doumbia - Institut d'Economie Rurale, Mali (Currently completing a PhD degree at TAMU)
Zoumana Kouyate - Institut d'Economie Rurale, Cinzana Station, Mali
Mamadou Kieta - Institut d'Economie Rural, Sotuba Station, Mali
D.T. Rosenow - TAES, Texas A&M University (INTSORMIL)
Lloyd Hossner - TAES, Texas A&M University

Samba Traore is Director of the Cinzana Experiment Station where research has been initiated and oversees research activities at the station. Zoumana Kouyate provides technical backstopping. Mamadou Kieta is director of the IER soils laboratory at Sotuba Experiment Station and expedites the chemical and physical analyses of soils. D.T. Rosenow provides technical backstopping for breeding line evaluations and as a source of seed. Lloyd Hossner provides technical backstopping on analytical procedures.

Objectives:

1. Develop analytical procedures for determining chemical and physical properties of Sahelian soils and diagnostic techniques to use in predicting crop response and need for fertilizers or corrective amendments;
2. Identify and define sorghum genotypes with varying levels of tolerance to drought and chemical stress of Sahelian soils and determine how each trait is inherited;
3. Breed multiple stress tolerant sorghums for use in Sahelian Africa that met selected grain quality and yield standards;
4. Quantify the interactions between sorghum genotypes, available water levels, and chemical properties (nutrient deficiency and toxicity) for Sahelian soils; and
5. Using multiple stress tolerant sorghums, develop best management practices that are economically feasible, promote sustainability and enhance natural resource management.

Progress Report: The first amendment to the interdisciplinary research project was approved by TropSoils, INTSORMIL, TAES and IER administrators in October 1992. A.B. Onken and G. Peterson (INTSORMIL) travelled to Mali from 10/12 to 10/24 to conduct site visits at several locations. The response of the sorghum growth at Cinzana was evaluated by project personnel. Based on this evaluation, plans and research techniques to be utilized at the site for screening sorghums for tolerance to the acid soil toxicity problem in Mali were completed.

A field plot location has been selected on the Cinzana Experiment Station to begin research on diagnostic techniques and the soil toxicity problem. This plot area was uniformly planted to sorghum and toxic spots mapped in 1992. Soil samples were taken from each toxic spot and adjacent normal areas. These samples were taken in 2.5 to 15 cm increments, since the toxicity manifests itself in the seedling growth stage of sorghum.

Work Planned for Next Year: The plot area at Cinzana will be planted to four replications of grain sorghum varieties and breeding lines. A paired plot planting technique will be used to begin screening genotypes for tolerance to the spatially variable soil toxicity problem. Dr. Aboubacar Toure will be responsible for this phase. Sorghums to be planted will be furnished by Drs. Toure, Peterson and Rosenow. Evaluation of the materials during the growing season will be completed by Dr. Toure. A final evaluation will be made by Drs. Toure, Onken and Peterson just prior to crop harvest. Chemical and physical analyses will be determined for soil samples taken previously and on soil and plant samples taken in toxic spots as plants died and in areas where plants grow normally. Also, based on the first year's mapping, soil samples and plant samples from genotypes that grew in these areas will be taken for comparison with analyses of genotypes that did not survive. Appropriate statistical procedures will be used by Dr. Toure for data analyses and completion of a report presenting results and conclusions.

CALENDAR OF EVENTS

EVENT	DATE
Plant crop (May), evaluate crop (May), collect soil and plant samples (May)	Present - September 1993
Crop evaluation in October (Toure, Onken and Peterson) Harvest crop in October Soil and plant analysis Data analysis	October - December 1993
Report writing	January - April 1994
Plant crop (May), evaluate crop (May), collect soil and plant samples (May)	May - September 1994

Research Sites: Cinzana Experiment Station, Mali

Budget (93-94): TAMU-03-B

Object	CRSP	External[a]	Matching	Host	Total
Salaries	4,656.62	3,500.00	2,879.00	10,000.00	21,035.62
Fringe benefits	1,163.13	525.00	812.00		2,500.13
Allowances	0.00	0.00			0.00
Consulting	0.00	0.00			0.00
Travel, US	579.77	0.00			579.77
Travel, INT[b]	5,159.53	5,000.00			10,159.53
Supplies	2,619.65	2,500.00		500.00	5,619.65
Equipment	0.00	4,500.00			4,500.00
Communications	579.77	500.00			1,079.77
Shipping/Freight	0.00	0.00			0.00
Publications	39.88	0.00			39.88
Other direct costs	1,590.00	1,590.00		750.00	3,930.00
Indirect costs	4,720.54	3,623.00	1,587.13		9,930.67
TOTAL	21,108.89	21,738.00	5,278.13	11,250.00	59,375.02

[a]External funds are those contributed by INTSORMIL.
[b]Travel includes in-country (Mali) travel by collaborators ($1,500) and travel to Mali by A.B. Onken in October 1993 ($3,500).

Subproject Number: TAMU-03-C

Title: Nutrient Deficiency and Toxicity Studies at the Cinzana Station, Mali

Collaborators and Institutions:

Mamadou Doumbia - Institut d'Economie Rurale, Mali (Currently a PhD student at Texas A&M University
Lloyd R. Hossner - TAES, Texas A&M University
Arthur B. Onken - TAES, Texas A&M University (Lubbock, TX)
Darell T. Rosenow - TAES, Texas A&M University (Lubbock, TX)
Zoumana Kouyate - Institut d'Economie Rurale, Mali

Objectives: The overall objectives of this project are to:

1. Define soil chemical properties associated with variable sorghum growth in sandy soils of the Cinzana toposequence; and
2. Define low input management practices to alleviate nutrient deficiency and toxicity in these soils.

Progress Report: A study was conducted to define P sorption characteristics of selected surface soils of the Cinzana toposequence. Soil characterization has now been completed. Phosphorus requirements to achieve optimum growth of most crops in these soils were estimated as the amount of P sorbed at 0.2 μg P mL^{-1} of solution. Soil on positions other than the toe slope required from 5 to 45 mg P kg^{-1} soil to attain this solution concentration. Phosphorus sorption in these surface soils was strongly correlated with clay content ($r = 0.94^{**}$), Fe oxides ($r = 0.91^{**}$), organic C ($r = -0.73^{**}$), and Bray-1 P ($r = 0.51^{**}$). Exchangeable Al was poorly correlated with P sorption ($r = 0.21$).

Digestion of the plant samples from the three field experiments (liming, manure, Tilemsi rock phosphate) has also been completed. These experiments were conducted for two consecutive growing seasons (1990 and 1991) at the Cinzana station. These samples are being analyzed for N, P, Ca, Mg, K, Al, Fe, Mn, Si, Zn, Mo, and B.

Work Planned for Next Year:

CALENDAR OF EVENTS

EVENT	DATE
Plant sample analysis	Present - December 1993
Soil sample analysis - Soil samples were taken from each of the above field experiments before treatment application and during each growing season. These samples will be analyzed according to the objectives set out above.	

CALENDAR OF EVENTS (continued)

EVENT	DATE
Soil solution studies - Soil solution will be extracted for selected samples from the three field experiments. The solutions will be analyzed for ionic strength and selected nutrients.	
Data analysis and writing of dissertation. Preparation of manuscripts for publication.	January - September 1994

Research Sites: Cinzana IER Research Station, Mali

Budget (93-94): TAMU-03-C

Object	CRSP	External	Matching	Host	Total
Salaries	13,483.16	0.00	4,098.00		17,581.16
Fringe benefits	4,318.29	0.00	1,156.00		5,474.29
Allowances	0.00	0.00			0.00
Consulting	0.00	0.00			0.00
Travel, US	602.29	0.00			602.29
Travel, INT	204.57	0.00			204.57
Supplies	1,153.43	0.00			1,153.43
Equipment	0.00	0.00			0.00
Communications	202.29	0.00			202.29
Shipping/Freight	0.00	0.00			0.00
Publications	1,051.14	0.00			1,051.14
Other direct costs	0.00	0.00			0.00
Indirect costs	9,036.53	0.00	2,259.22		11,295.75
TOTAL	30,051.70	0.00	7,513.22	0.00	37,564.92

SOIL MANAGEMENT CRSP
ANNUAL ACTIVITY WORK PLAN AND BUDGET REQUEST

Fiscal Year: 1993-1994

Project Number: CU-02

Title: Pathways of Nutrient Flow in Relation to Plant Utilization of Nitrogen and Phosphorus

Global Thrust: Sustainable Agriculture

Constraints Addressed: Nutrient deficiencies and losses, land clearing pressure, and production-demand pressure

Principal Investigators and Institutions:
John M. Duxbury - Cornell University
Jean Fruci - Cornell University
Ken Schlather - Cornell University

Collaborators and Institutions:
Alfredo Alvarado - University of Costa Rica
Jorge Briceno - University of Costa Rica
Elemer Bornemisza - University of Costa Rica

Dr. Alvarado serves as in-country supervisor of Ken Schlather. Dr. Briceno and Ken Schlather will carry out joint experiments (see work plan) at UCR. Dr. Bornemisza is a resources scientist providing advice on the phosphorus chemistry of Costa Rican soils.

Objectives: The long-term goal of this project is to provide information on nutrient management that will enable farmers to derive maximum benefit from their production systems while maintaining long-term productivity. Specific objectives are to:

1. Develop a better understanding of N transformations in soil-plant systems so that sound recommendations can be made to farmers regarding management of both endogenous and applied N; and
2. Explore the potential benefits of slash/mulch systems of crop production and develop methodologies for P management in mulch and organic surface layers of such systems to avoid P fixation in underlying mineral horizons.

Progress Report: During this period, analysis of soil, plant materials, extracts, etc. collected from research sites at Canas, Costa Rica and Ithaca, New York were completed. The purpose of this project was to compare N dynamics in an annual crop (wheat at Ithaca, NY) with that in a perennial crop (pastures at Canas, Costa Rica and Ithaca, NY). Jean Fruci, the student working on this project has begun writing her Ph.D. thesis. Two field experiments comparing effects of different fertilizer practices on bean production by conventional row crop agriculture and the traditional slash/mulch system

(frijol tapado) were carried out near San Vito in southern Costa Rica. One experiment, on an Andisol, was collaborative with scientists from the University of Georgia. It involved five replications of four fertilizer treatments in four newly established alley cropping systems. The second experiment made similar comparisons, but without alley crops, on an Ultisol. Additionally, a preliminary trial investigating the effects of different mulch species on bean germination, nutrient uptake, weed control, and nematode control was carried out at the Andisol site. Sample analysis from these experiments will be completed prior to the next cropping season (Oct-Nov 1993). A farmer survey to elucidate frijol tapado practices was initiated in collaboration with Martha Rosemeyer (OTS, Wilson Botanical Garden).

Work Planned for Next Year: It is expected that Jean Fruci will complete her Ph.D. thesis by the end of 1993. During the summer and fall 1993 Ken Schlather and Jorge Briceno will carry out a joint greenhouse pot experiment to study the decomposition of different mulch materials and effects of decomposition on nutrient availability. This experiment will be carried out at UCR. John Duxbury will visit Ken Schlather and UCR scientists in early fall to complete plans for next year's field experiments.

Research Sites: Field research is being carried out at two sites (andisol and ultisol) near San Vito, Costa Rica. Greenhouse experiments and laboratory analysis will be carried out at Centro de Investigaciones Agronomicas, University of Costa Rica. Sample preparation and simple laboratory tasks will be done at the Wilson Botanical Garden (OTS facility at San Vito).

BUDGET (93-94): CU-02

OBJECT	TOTAL FUNDING SOURCE CRSP	EXTERNAL	MATCHING HOST	TOTAL
Salaries				
GRA (1) Stipend	13,475			13,475
GRA (1) Fees	4,468			4,468
J. Duxbury (10%)			6,181	6,181
Administrative Support	500			
Fringe Benefits @28.97%	145			
Matching F.B. @ 36.78%			2,273	2,273
Allowances (GRA & PI)*	12,000			12,000
Visiting Scientist				0
Consulting				
Travel				
US	1,000			1,000
International	3,000			3,000
International (off-campus)	3,000			3,000
Supplies	5,000			5,000
Equipment				0
Communications	300			300
Analytical Costs				0
Publication	2,000			2,000
Other direct costs	8,000			8,000
TOTAL DIRECT COSTS	52,888		8,455	61,343
Indirect Costs				
On-Campus	17,713		4,481	22,194
Off-Campus (* = Off-Campus)	4,500			4,500
TOTAL PROJECT COSTS	75,100		12,936	88,036

Human Resource Commitments:

INSTITUTION	FULL TIME EQUIVALENTS (FTE) SCIENTIST SENIOR	JUNIOR	TECHNICIAN	ADM. SUPPORT	OTHER	TOTAL
US	0.10	2.00	0.04			2.14
HOST	0.25					0.25
OTHER						
TOTAL	0.35	2.00	0.04			2.39

Date Initiated:

Expected Completion: August 20, 1995

SOIL MANAGEMENT CRSP
ANNUAL ACTIVITY WORK PLAN AND BUDGET REQUEST

Fiscal Year: 1993-1994

Project Number: UH-04

Title: Maize/Legume/Rhizobium Systems: Interspecific Interactions, Nitrogen Fixation, and Yield Responses on Acid Soils

Global Thrust: Natural Resource Management, Sustainable Agriculture, and Outreach

Constraints Addressed: Inability to integrate basic process-level information on crop/soil interactions (*i.e.*, nitrogen cycling, moisture stress, aluminum toxicity) so that decision makers can solve applied problems. Lack of information tools that synthesize the knowledge generated by numerous groups of soil scientists around the world. Lack of methods for translating the knowledge in ways that allow the knowledge to be easily delivered and understood by problem solvers.

Principal Investigators and Institutions:

Robert Caldwell - Project Leader, University of Hawaii (responsible for overall coordination)

Paul Singleton - Niftal/University of Hawaii (responsible for integrating ongoing Niftal research into the agroecosystem approach, particularly research on the modeling of biological nitrogen fixation, BNF, conducted in part by graduate student Surya Tewari; also responsible for defining client needs for decision support tools related to rhizobium inoculation and BNF)

Collaborators and Institutions:

Basil Acock - USDA/ARS, Beltsville, Maryland (models of biological nitrogen fixation in legumes; models of alleycrop systems)

Abdul Ghani - Sukarami Agricultural Research Institute for Food Crops, Sukarami, Indonesia (user advisory group; information technology evaluation)

Robert Grant - University of Alberta, Edmonton, Alberta, Canada (supercomputer-based approaches to agroecosystem modeling)

C. Allan Jones - Texas Agricultural Experiment Station, Temple, Texas (generic models of cropping systems; ALMANAC)

James W. Jones - University of Florida (decision support system technology; biological nitrogen fixation in legumes)

Susan Miyasaka - University of Hawaii (modeling aluminum toxicities)

Tasman Naim - Sukarami Agricultural Research Institute for food Crops, Balittan/Sitiung, Indonesia (user advisory group; information technology evaluation)

Agus Sofyan - Center for Soil Research, Bogor, Indonesia (user advisory group; information technology evaluation)

Collaborators and Institutions: (continued)

I P.G. Widjaja-Adhi - Center for Soil And Agroclimate Research, Bogor, Indonesia (user advisory group; information technology evaluation)

Objectives: The primary goal of this project is to increase the sustainability and resource-use efficiency of cereal/legume cropping systems, applying simulation-based decision support tools to improve system management. This is to be accomplished by:

1. Quantifying processes central to understanding and modeling cereal / legume / rhizobium systems, especially interspecific interactions: (a) biological nitrogen fixation, (b) resource competition, and (c) root systems interactions.
2. Evaluating cereal/legume multiple cropping systems and (a) identifying the levels of lime and fertilizer substitution to be expected by either rotating or intercropping, and (b) identifying optimum cropping patterns (*i.e.*, sequences to use for double or triple cropping).
3. Comparing contrasting agroecosystem models for their abilities to simulate and screen multiple cropping systems on acid soils, and training researchers and implementers in the capabilities and requirements of the models.

Progress Report: With the help of Anthony Fernandez, a half-time computer programmer, we were able to write a number of small programs that simplify the operation of CropSys and other simulation models. Users with very little knowledge of computers can now select from a range of simulation options, run the models, view graphs of observations and predictions, change options and rerun the models. For example, a student recently used these programs with a simulation model from the Soil Conservation Service's Water Erosion Prediction Program to develop a "miniapplication" that teaches the dynamics of soil erosion and assesses the impact of crop management on soil erosion. Additional miniapplications were created by other students and Mr. Fernandez. Documentation of the software is ongoing.

R. Caldwell visited Chiang Mai, Thailand, and discussed the use of simulation models with faculty and students at Chiang Mai University and with local scientists in the Upland Rice Research Consortium. Dr. Jongkaewattana at the University has agreed to coadvise with R. Caldwell a graduate research assistant on the testing of agroecosystem simulation models under Thailand conditions.

CropSys was demonstrated at two professional meetings: the ASA (1992 Agron Abstracts, p. 79) and the 1993 Global Planning Session for the CRSP. C. Allan Jones and R. Caldwell discussed progress with ALMANAC (an intercrop model) at the later meeting.

The second Miniworkshop on Multispecies Modeling was presented in conjunction with the 23rd Annual Workshop on Crop Simulation, April 5 to 7, 1993 in Phoenix, AZ. The miniworkshop, organized by R. Caldwell, was given an entire morning of the workshop. Basil Acock gave a presentation on two-dimensional models and their application in alleycropping and intercropping. Robert Grant discussed his research on supercomputer-based agroecosystem simulation.

Herve Sinoquet, French scientist stationed in Guadeloupe, French Antilles, spent two weeks in R. Caldwell's lab studying CropSys. Dr. Sinoquet recently has published a

series of articles on modeling intercrops. He will collaborate on testing CropSys with data from low-input (*i.e.*, zero N fertilizer) maize/field bean systems in the Carribean.

Three graduate students at the University of Hawaii (Jon Kamemoto, M.S.; Lokugam Gunaratne, M.S.; San-Gwang Hwang, Ph.D., each with support from outside the CRSP) are currently finishing the second season of an intercrop modeling trial on the island of Oahu, Hawaii.

Work Planned for Next Year The central focus of work in this final year of the project will be to develop and test the problem-solving capabilities of agroecosystem simulation models. Miniapplications (sets of data and models that teach or help decision makers on specific management problems) are planned for:

- Biological nitrogen fixation in sequential cropping versus intercropping.
- Selection of intercrop density combinations as influenced by the magnitude of soil stresses.
- Long-term cropping systems comparisons: risk and sustainability assessments.
- Genetic considerations for soil management: cultivar differences in the timing of water use.
- Intercropping on acid soils.
- Nitrogen losses from cropping systems: a mass-balance approach for integrated management.
- Competition for resources in strip intercrop systems.
- Whole-farm simulation: farm-level resource constraints to soil management.

Other mini-applications may be developed as an outgrowth of interactions with our client groups, particularly U.S. AID missions and national scientists.

These clients and researchers at a number of international sites will participate in testing the quality of agroecosystem simulation models. Visits are planned to sites that have datasets available to test the models. Workshops will be conducted in conjunction with these visits to teach scientists and decision makers how to use the models, their limitations, and implications of the models for guiding field experimentation and agricultural development.

A third miniworkshop on multispecies simulation is being planned for Spring 1994. That meeting will provide an opportunity for collaborators to meet in a central location to share experiences with the models and to make final recommendations on the design of CropSys and the mini-applications.

As users provide feedback on software design, modifications will probably become necessary. This project will support a computer programmer to make the modifications and to assist in writing program documentation. The programmer will also help develop the mini-applications.

San-Gwang Hwang will continue his doctoral program on intercrop simulation (self-supported). Scientists at the Asian Vegetable Research and Development Center are being contacted about collaboration during the field research phase of Mr. Hwang's program. (Multiple cropping with vegetables may be an important part of planned work with the Upland Rice Research Consortium.)

Time-line

1993			1994								
O	N	D	F	M	A	M	J	J	A	S	O

Research Sites: Operations support for the field research in Hawaii is covered by a USDA/CSRS special grant managed by the Pacific Basin Advisory Group. No Soil Management CRSP funds will be used for international research site operations other than for travel for the principal investigators. Cooperators in Nigeria, India, the Caribbean, and Thailand have completed or have ongoing experiments sponsored from other sources of funds. These will be used to fulfill the need for experimental data, as outlined in the project objectives.

Budget:

	Total Funding Source				
Object	CRSP	External[a]	Matching	Host[b]	Total
Salaries[c]	13000	20000	11500	10000	54500
Fringe Benefits	2700	1000	3000	0	6700
Allowances	0	0	0	0	0
Consulting	0	0	0	0	0
Travel, US	0	2000	0	0	2000
Travel, INT[d]	9500	0	0	1000	10500
Supplies[e]	1000	3500	0	0	4500
Equipment	0	3500	0	0	3500
Communications	500	0	0	0	500
Shipping/Freight	0	0	0	0	0
Publication	1000	0	0	0	1000
Direct costs	27700	30000	14500	11000	83200
Indirect Costs	12188	0	0	0	12188
Total	39888	30000	14500	11000	95388

[a]USDA/CSRS Special Grant, managed by the Pacific Basin Advisory Group, "Sustainability of taro-based cropping systems," Caldwell, El-Swaify, Uehara.
[b]During international travel, host institutions will cover all or part of in-country travel and living expenses.
[c]Half-time computer programmer.
[d]Visit with international collaborators; see time line.
[e]Software upgrades and incidental computer supplies.

Special Budget Requirements: N/A

Human Resource Commitments: Mr. Anthony Fernandez is employed as a computer programmer and will be supported on a half-time basis. Caldwell will be on sabbatical leave and will coordinate programming activities on CROPSYS with Fernandez via email.

Full Time Equivalents (FTE)

INSTITUTION	SENIOR	TECHNICIAN	TOTAL
US			
R. Caldwell	0.2		0.2
A. Fernandez		0.5	0.5
Host			
Other			
Total	0.2	0.5	0.7

Date Initiated: October, 1990

Expected Completion: October, 1994

Signatures:

Principal Investigator	Date	Program Coordinator	Date

SOIL MANAGEMENT CRSP
ANNUAL ACTIVITY WORK PLAN AND BUDGET REQUEST

Fiscal Year: 1993-1994

Project Number: CU-03

Title: Utilization of Green Manures in Cropping Systems

Global Thrust: Utilization of Green Manures, Outreach, Natural Resource Management

Constraints Addressed: Zn and P in Cameroon, leaching and recycling of nutrients in Costa Rica.

Principal Investigators and Institutions:
David R. Bouldin - Cornell University
Raphael Salas - CIA, University of Costa Rica
Titus Ngoumou - NCRE, Cameroon.

Collaborators:
Titus Ngoumou - Cameroon. Mr Ngoumou is the link between TropSoils and NCRE. NCRE has furnished, is furnishing and is committed to furnish support for field operations in Cameroon.
Raphael Salas - Costa Rica. Mr Salas is the link to CIA (Agronomic investigation Center), University of Costa Rica and the Rio Frio Experiment Station, all cooperators on the project.
Cooperating scientists are Dr. Alfredo Alvarado, Director of CIA, Ing Eloy Molina and Ing Vidal Vega. The collaborators are furnishing the experimental site and considerable on-site support for the necessary field operations.

Objective: The long-term objective of the project is to develop useful cropping systems that utilize legume green manures to supply N, reduce erosion, enhance organic matter content, suppress nematodes (where they are troublesome), and perhaps recycle nutrients leached from the surface layers of soil. The specific objective of the work in Cameroon is to reduce the yield limitations of Zn and P on growth of legume green manures and maize. The specific objective of the work in Costa Rica is to study water and nutrient uptake by maize and legume green manures from the lower horizons of the soil. This is a continuation of the work begun by Dr. Cahn in Manaus, Brazil.

Progress Report: During the past year, projects in Costa Rica and Cameroon have moved forward. Presently, Mr. Titus Ngoumou is in Cameroon setting out field experiments to measure response to Zn and P and to calibrate soil tests for both Zn and P and their interactions. Soil samples were collected from Cameroon and from NY. Several extractants for Zn were compared and used to select the experimental sites in Cameroon. Mr. Raphael Salas has collected soil samples from a Costa Rican experiment set up three years ago. The samples are now being analyzed. He is calibrating soil

moisture equipment, which will be used to monitor water utilization by maize and selected legume green manures in this experiment during the next year.

Experimental Plans: Mr. Ngoumou is now setting up experiments at 6 to 10 locations in Cameroon. They will consist of a factorial combination of Zn and P. Soil and plant samples will be taken this fall and analyzed in Ithaca. Next year residual effects will be monitored at the same locations. During the next year simple methods of analysis of soil extracts for Zn and P will be developed, since experience in developing countries has demonstrated that it is unlikely that modern AA equipment can be maintained. Mr. Salas will monitor water utilization by maize and selected legume green manures by depth beginning in the summer of 1993 and continuing into the next fiscal year. This utilizes an established and on-going experiment. Soil samples will be analyzed and the legumes evaluated with respect to their ability to translocate nutrients (*e.g.*, Ca, Mg, K) to the surface for recycling. This is a continuation of the experiments begun in Manaus by Dr. Cahn.

Narrative Explanation of Human Resources: Mr. Ngoumou will coordinate our work with NCRE. Mr. Salas will coordinate the work with the Costa Rican institutions and personnel. Professor Bouldin is the coordinator for Cornell.

BUDGET (93-94): CU-03

OBJECT	TOTAL FUNDING SOURCE CRSP	EXTERNAL	MATCHING	HOST	TOTAL
Salaries					
GRA (1.0) Stipend	13,475				13,475
GRA (1.0) Fees	4,468				44,468
D. Bouldin (15%)			12,300		12,300
Administrative Support	500				
Fringe Benefits @28.97%	145				
Matching F.B. @ 36.78%			4,524		4,524
Allowances (GRA & PI)*	3,000				3,000
Visiting Scientist					0
Consulting					
Travel					
US	1,000				1,000
International	7,000				7,000
Supplies	5,000				5,000
Equipment	5,000				5,000
Telecommunication and Copying	500				
Analytical Costs	10,000				
Publication					
Other direct costs	5,000				
TOTAL DIRECT COSTS	55,088		16,824		71,912
Indirect Costs					
On-Campus	22,589		8,917		31,505
Off-Campus (* = Off-Campus)	900				
TOTAL PROJECT COSTS	78,576		25,741		103,417

INSTITUTION	FULL TIME EQUIVALENTS (FTE) SCIENTIST SENIOR	JUNIOR	TECHNICIAN	ADM. SUPPORT	OTHER	TOTAL
US	0.15	1.00		0.04		1.19
HOST	0.50					0.50
OTHER						0.00
TOTAL	0.65	1.00	0.00	0.04		1.69

Date Initiated:

Expected Completion: August 20, 1995

SOIL MANAGEMENT CRSP
ANNUAL ACTIVITY WORK PLAN AND BUDGET REQUEST

Fiscal Year: 1993-1994

Project Number: UH-05

Title: Tree-Crop-Soil Interactions in an Agroforestry System

Global Thrust: Soil Fertility and Efficient Use of Resources

Constraints Addressed: Natural Resource Management

In agroforestry systems, it is hoped that crops grown in close association with trees will benefit from nutrients stored by the trees during fallow periods, nutrient retrieval from depths beyond the crop root zone, nitrogen inputs if the trees are nitrogen fixing, and (sometimes) the moderation of extreme temperatures by shading. The farming system as a whole may benefit when tree leaves or pods are used as livestock fodder or when wood is used or sold. Working against these potential benefits is competition between trees and crops for plant growth resources (light, water, and nutrients).

When alley cropping systems, in particular, have failed to outproduce sole cropping systems, these failures often have been attributed to high levels of competition between the trees in the hedgerows and the crops in the alleys. Although shading has been universally observed, its effects on crop growth in alley crops seldom have been quantified (Lawson and Kang, 1990). Mulch from trees in an agroforestry system benefits the nutrient status of the crops only if the nutrients supplied in the mulch become available to the crops and are not taken back up by the trees. Although the sum total of nutrients supplied in the form of mulch may be enough to sustain crops at moderate yields (Szott *et al.*, 1991b), it is not known how much of these nutrients is in fact taken up by the crops and how much is recycled by the trees.

Lack of a mechanistic understanding of tree-crop-soil interactions prevents sound recommendations of candidate species and management strategies. The proposed research seeks to quantify two aspects of tree-crop competition—that for light and that for nutrients—and in this context will attempt to evaluate management strategies to improve crop growth.

Principal Investigators and Institutions:

James H. Fownes - University of Hawaii, Honnolulu, HI
J.B. Friday, University of Hawaii

Collaborators and Institutions:

Dennis Garrity - International Centre for Research in Agroforestry (ICRAD), Bogor, Indonesia.

The proposed research will benefit from existing collaborative linkages with the International Center for Research in Agroforestry (ICRAF), headquartered in Nairobi,

Kenya, with the Southeast Asian office in Bogor, Indonesia. J.B. Friday has been working with alley cropping systems for eight years, both in the Philippines and in Hawaii. Since 1991 he has been pursuing a Ph.D. at the University of Hawaii. The TropSoils project is being asked to fund a graduate assistantship for Mr. Friday and to provide some operations and travel support.

Lead Institution and Coordinating Scientist:
University of Hawaii, James H. Fownes

Problem Statement and Justification: Understanding tree-crop-soil interactions is a prerequisite to successful management of tropical agroforestry systems. Evidence is accumulating that anticipated benefits of agroforestry systems are more difficult to obtain on acid soils of the tropics than was originally anticipated, primarily because of tree-crop competition and inherently low soil fertility (Szott *et al.*, 1991a). Minimizing tree-crop competition is crucial to ensuring success in agroforestry.

In these studies we propose to investigate tree-crop competition for light and for potassium. Light competition is inherent in any alley cropping system, yet available light may not be the limiting factor to crop production (Singh *et al.* 1989). Potassium is a key element to study both because it is often limited in the acid upland soils common in the tropics (Gill and Kamprath, 1990) and because of its mobility in the soil. If nutrient competition is taking place, potassium would be among the first elements to show effects of competition (Gillespie, 1989). In acid soils where K is being leached, trees might benefit the crops by storing K over the fallow period and preventing leaching or by "pumping" up K from soil below the crop root zone.

We plan to develop a model to describe light interception by the hedgerows and to gather data on how much potassium is taken up by trees from the alley under the crops. With these and other such models, we will be able to begin to predict how a given tree and crop will interact in a given environment avoid the need for infinite trials of all possible combinations and spacings. We will be able to judge which of the various forms of competition are most important to crop growth. Models and process-level information such as we seek are needed to develope decision support tools for agroforestry. With these tools, we will be able to select trees and crops that complement each other in their resource use and better manage all aspects of alley cropping, including timing of prunings, spacing of plants, and selection of cultivars, to optimize crop yield. We propose beginning the research in Hawaii to develop methods that could then be used internationally in alley cropping research.

Following the methods development phase, we propose beginning similar measurements in cooperation with ICRAF and the IRRI Upland Rice Consortium, which is currently in the planning phase for research in Sitiung (Indonesia), Claveria (Philippines), and northeast Thailand. We are requesting support to travel to consortium sites, meet with participating scientists, learn about their ideas and research needs, and present preliminary results from our experiments.

Objectives: The overall goal of this research is to understand the mechanisms of tree-crop-soil interactions in an alley cropping system, to develop principles for extrapolation to various sites, and to optimize knowledge-based management practices.

Specific objectives are to:

1. Quantify mechanisms of tree-crop competition for light by:

   - Testing the hypothesis that pattern of reduction in maize growth with distance from hedgerow is correlated with light reaching crop;
   - Testing the hypothesis that shading is a sufficient explanation for crop growth reduction (versus below-ground competition);
   - Refining computer models of light interception and growth by hedgerows; and
   - Integrating experimental results with CropSys and comparing field results with predictions of maize model.

2. Trace the fate of K in the tree-crop-soil system by:

   - Testing the hypothesis that fertilizer recovered from surface soil is proportional to relative K uptake by trees and crops (versus greater than proportional, indicating competitive ability, or less than proportional, indicating partitioning of resource use)
   - Testing the hypothesis that the amount of K recovered from green manure is proportional to the relative uptake of trees and crops

Review of Previous Research:

Competition in Alley Cropping. Alley cropping was developed as an alternative to forest fallowing as a method of regenerating soil fertility through *in situ* growth and application of green manure. Kang *et al.* (1981) attempted to minimize above ground competition between trees and crops by pruning hedgerows frequently and to minimize below-ground competition by choosing a tree species (*Leucaena leucocephala*) with a deep rooting habit and tilling the surface soil. With these methods they were able to maintain crop yields at acceptable levels for years (Kang *et al.* 1985). Other alley cropping trials have not been as successful. In the very low base status soils of Yurimaguas, Peru, Szott *et al.* (1991) found that alley cropping was not sustainable and hypothesized that a large factor in the failure to sustain crop yields was excessive tree-crop competition. Similarly, in Sitiung, Indonesia, researchers with the TropSoils project were unable to maintain rice yields in an alley cropping system on highly leached soils without chemical fertilizer inputs (Evensen, 1989, Dierolf, pers. comm.), and researchers in Claveria, the Philippines, have consistently found yield depression in crop rows bordering the hedgerow trees (Garrity *et al.* 1992).

Light Competition. Competition for light is probably the form of tree-crop competition most often hypothesized in the literature (Kang *et al.* 1981, Lal, 1989, Evensen, 1989, Lawson and Kang, 1990), although it has seldom been unequivocally demonstrated. Kang *et al.* (1981) found a slight depression in the yield of maize in the rows bordering the trees of their alley cropped plots relative to the center rows when no fertilizer was applied but a much greater depression when N was applied. They attributed this to light competition from the hedgerows becoming significant once the nitrogen stress was

eliminated. Lawson and Kang (1990) correlated the degree of shading in an alley crop with crop yields, but their method of changing the amount of shade was to trim the hedgerows. As this probably also caused extensive root dieback (Fownes and Anderson, 1991) and thus affected water and nutrient uptake by the hedgerows, it cannot be shown unequivocally that light competition rather than water or nutrient competition caused the declines in crop yields.

Models of Light Interception. Models of light interception for agroforestry systems allow experimentation with the height and arrangement of the trees to maximize the light yield transmitted to the crops. Jackson and Palmer (1972) developed a model of light interception by rows of trees from the solar geometry and the orientation, shape, and spacing of the rows of trees. They modeled the rows of trees as opaque, non-reflecting prisms of varying cross sections. Jim Fownes has developed a computer model based on their equations and adapted it for teaching about alley cropping (Fownes, 1992). Palmer (1977) further modified his model to include transmission through the hedgerows. In general, light absorbed by plant canopies can be described by a modification of Beer's law:

$$\text{Fraction of light absorbed} = 1-\exp(-k*LAI)$$

where k is a constant, and leaf area index (LAI) is used in place of the thickness of the transmitting material (Rosenberg *et al.* 1983). Palmer's 1977 model calculated light absorbed by hedgerows by calculating the length of the path of the solar rays through the hedgerow and calculating a leaf area density of the hedgerows.

The Cropsys model of intercropping calculates a leaf area index and canopy height for each species and uses these values to partition daily net radiation. Incident light is first absorbed by the portion of the canopy of the taller species that projects above the canopy of the shorter species. Light transmitted through this portion of the canopy is then partitioned between the two species, based on the relative LAIs of the two species (Caldwell, pers. comm.).

Tree Growth Models. Models of light interception ideally should be based on leaf area. Leaf area may be measured by successive destructive harvests, but a more generalizable approach is to model tree growth based on leaf area and biomass allometries. Fownes and Harrington (1990) developed a tree growth model based on the net assimilation rate, the rate of biomass added per unit leaf area per unit time. Growth may also be modeled based on radiation intercepted multiplied by a radiation conversion efficiency. Linder *et al.* (1985) modeled growth for Eucalyptus using this approach. Intercepted radiation, in turn, is a function of leaf area, as described above. Harrington and Fownes (in review) have also measured radiation conversion efficiencies of coppice trees.

Nutrient Competition. Several studies on below-ground competition have included treatments where trenches were dug along the hedgerows or the alleys were cultivated (Kang *et al.*, 1981, Evensen, 1989, Garrity *et al.*, 1992). Singh *et al.* (1989) were able to completely eliminate yield depression in crop rows bordering the hedgerows by

digging trenches between the hedgerows and the crops and installing impermeable root barriers. Although they concluded that their results proved that the hedgerows were competing with the crops for water, the yield depression in the untrenched plots could also have been because of nutrient stress.

Some studies have tried to assess potential root competition by measuring root biomass in the soil at various depths and distances from the hedgerows (Ruhigwa *et al.* 1992, Kang *et al.* 1981). However, root activity, in terms of either water or nutrient uptake, changes over time, is not well correlated with root biomass (Huxley *et al.*, 1974, Rendig and Taylor, 1989). Kang *et al.* (1985) looked for evidence of root activity by following moisture depletion at different depths across the alley. They found that there was a significant zone of moisture depletion at a greater depth than where they expected to find maize roots and concluded that this was evidence that the hedgerow trees were obtaining moisture, and by association nutrients, from levels deeper in the soil than where the crops were found.

Nutrient-labeling Studies. A more elegant way of studying root nutrient uptake is by labeling experiments. Huxley *et al.* (1974) studied root activity in coffee by applying P-32 at various depths and distances from the stem and then sampling the foliage. An alternative to using isotopes as tracers is to use analogous elements. The rubidium ion has the same charge and approximately the same ionic radius as the potassium ion (Diest and Talibudeen, 1967) and is similarly taken up by plants (Fried *et al.*, 1959). It has been used in both plant and soil studies to follow movement of potassium (Salisbury and Ross, 1985). Since potassium, unlike phosphorus, moves readily in the soil, it should show effects of nutrient competition sooner, if any exists (Gillespie, 1989). Since potassium fertilizers are low in rubidium compared with natural soil levels, dilution of natural rubidium levels may be used to measure K uptake from fertilizer (Hafez and Stout, 1973). This technique has been used to determine long-term K cycling in forest plantations (Stone and Kszystyniak, 1977, Stone, 1981.)

For rubidium to act as a tracer for potassium, it must competitively inhibit the uptake of K. Some studies have shown preferential fixing of Rb over K in soils (Franklin and Snyder 1965) or discrimination in uptake by excised plant tissues (Behl and Jeschke, 1982, Franklin and Snyder, 1965, Jacoby and Nissen, 1977, Marschner and Schimansky, 1971). Discrimination between elements does not invalidate the use of one as a tracer for the other, as long as the factor is constant and known. This is probably not a problem in non-K-fixing, kaolinitic soils (Franklin and Snyder, 1965.) In the proposed study, suitability of the Rb/K tracer technique must be determined in a pot study before proceeding with the field experiment.

References

Behl, R. and W. D. Jeschke. 1982. Potassium fluxes in excised barley roots, *J. of Exp. Bot.* 33(135):584-600.

Diest, J. and O. Talibudeen. 1967. Rb-86 as a tracer for exchangeable K in soils, *Soil Science* 104(2):119-122.

Evensen, C. 1989. Alley cropping and green manuring for upland crop production in west Sumatra. Ph.D. dissertation, University of Hawaii, Department of Agronomy and Soil Science.

Fownes, J. H. 1992. Hedgerad, Unpublished manuscript.

Fownes, J. H., and D. G. Anderson. 1991. Changes in nodule and root biomass of Sesbania sesban and Leucaena leucocephala following coppicing, *Plant and Soil* 138: 9-16.

Fownes, J. H. and R. A. Harrington. 1990. Modeling growth and optimal rotations of tropical multipurpose trees using unit leaf rate and leaf area index, *J. of Appl. Ecol.* 27:886-896.

Franklin, R. E. and G. H. Snyder. 1965. Ionic relationships in clay suspensions and dialyzates: I. Rb-86 as a tracer for K, *Soil Sci. Soc. of Am. Proc.* 29:508-510.

Fried, M, G. Hawkins and W. Mackie. 1959. Rb-K relationships in the soil-plant system. *Soil Sci. Soc. of Am. Proc.* 23: 360-362.

Garrity, D. P., A. Mercado and C. Solera. 1992. The nature of species interference and soil changes in contour hedgerow systems on sloping acidic lands. Paper presented at the International Conference on Alley Farming in IITA, Ibadan, Nigeria, 14-18 September 1992.

Gill, D. W. and E. J. Kamprath. 1990. Potassium uptake and recovery by an upland rice-soybean rotation on an oxisol, *Agrn. J.* 82: 329-333.

Gillespie, A. R. 1989. Modelling nutrient flux and interspecies root competition in agroforestry interplantings, *Agroforestry Sys.* 8: 257-265.

Hafez, A. A. R. and P. R. Stout. 1973. Use of indigenous soil rubidium absorbed by cotton plants in determining labile soil potassium pool sizes, *Soil Sci. Soc. of Am. Proc.* 37:572-579.

Harrington, R. A., and J. H. Fownes. Relative growth rates and radiation conversion efficiencies of planted and coppice stands of four fast-growing tropical tree species, *J. of Appl. Ecol.*, in review.

Huxley, P. A., R. Z. Patel, A. M. Kabaara and H. W. Mitchell. 1974. Tracer studies with 32P on the distribution of functional roots of arabica coffee in Kenya, *Ann. Appl. Biol.* 77:159-180.

Jackson, J. E. and J. W. Palmer. 1972. Interception of light by model hedgerow orchards in relation to latitude, time of year, and hedgerow configuration and orientation, *J. of Appl. Ecol.* 9:341-357.

Jacoby, B., and P. Nissen. 1977. Potassium and rubidium interaction in their absorption by bean leaf slices, *Physiologia Plantarum* 40:42-44.

Kang, B. T, H. Grimms and T. L. Lawson. 1985. Alley cropping sequentially cropped maize and cowpea with Leucaena on a sandy soil in southern Nigeria, *Plant and Soil* 85:267-277.

Kang, B. T., L. Reynolds and A. N. Atta-Krah. 1990. Alley farming, *Adv. in Agrn.* 43: 315-359.

Kang, B. T., G. F. Wilson and L. Sipkins. 1981. Alley cropping maize (Zea mays L.) and leucaena (*Leucaena leucocephala* Lam) in southern Nigeria, *Plant and Soil* 63: 165-179.

Lal, R. 1989. Agroforestry systems and soil surface management of a tropical alfisol. I. Soil moisture and crop yields, *Agroforestry Sys.* 8:7-29.

Lawson, T. L., and B. T. Kang. 1990. Yield of maize and cowpea in an alley cropping system in relation to available light, *Ag. and For. Met.* 52:347- 357.

Linder, S., R. E. McMurtrie and J. J. Landsberg. 1985. Growth of Eucalyptus: a mathematical model applied to *Eucalyptus globulus*, pp. 117-126 *in*: Crop Physiology of Forest Trees, P. M. A. Tigerstedt, P. Puttonen and V. Koski, eds., University of Helsinki, Helsinki, Finland.

Marschner, H. and C. Schimansky. Suitability of using rubidium-86 as a tracer for potassium in studying potassium uptake by barley plants, *Zeitschrift fuer Pflanzenenerhahrung und Bodenkunde* 128(2):129-143.

Maclean, R. H., J. A. Litsinger, K. Moody and A. K. Watson. 1992. Increasing Gliricidia sepium and Cassia spectabilis biomass production, *Agroforestry Sys.* 20:199-212.

Palmer, J. W. 1977. Diurnal light interception and a computer model of light interception by hedgerow apple orchards, *J. of Appl. Ecol.* 14:601-614.

Rendig, V. V. and H. M. Taylor. 1989. Principles of Soil-Plant Interrelationships. McGraw Hill, New York. 275 pp.

Rosenberg, N. J., B. L. Blad and S. B. Verma. 1983. Microclimate: The Biological Environment, 2nd ed., John Wiley and Sons, New York. 495 pp.

Ruhigwa, B. A., M. P. Gichuru, B. Mambaru and N. M. Tariah. 1992. Root distribution of *Acioa barteri*, *Alchornea cordifolia*, *Cassia siamea*, and *Gmelina arborea* in an acid ultisol, *Agroforestry Sys.* 19:67-68.

Salisbury, F. and C. Ross. 1985. Plant Physiology, Wadsworth Publishing Co., Belmont, CA, 540 pp.

Singh, R. P., C. K. Ong and N. Saharan. 1989. Above and below ground interactions in alley cropping in semi-arid India, *Agroforestry Sys.* 9:259- 274.

Smucker, A. J. M., B. G. Ellis and B. T. Kang. 1992. Root, nutrient, and water dynamics in alley cropping on an alfisol in forest savanna transition zone, Paper presented at the International Conference on Alley Farming in IITA, Ibadan, Nigeria, 14-18 September 1992.

Stone, E. L. 1981. Persistence of K in forest ecosystems: further studies with the Rb/K technique, *Soil Sci. Soc. of Am. J.* 45:1215-1218.

Stone, E. L. and R. Kszystyniak. 1977. Conservation of K in the *Pinus resinosa* ecosystem, *Science* 198:192-194.

Szott, L. T., C. A. Palm and P. A. Sanchez. 1991a. Agroforestry in acid soils of the humid tropics, *Adv. in Agrn.* 45:275-301.

Szott, L. T., E. C. M. Fernandes and P. A. Sanchez. 1991b. Soil-plant interactions in agroforestry systems, *For. Ecol. and Mgmt.* 45:127-152.

Work Plan for Next Year:

1. *Sites*

We propose to carry out the field studies at the University of Hawaii's Kauai Branch Station at Kapaa, Kauai. The station's climate and soils are similar to those widely found in the tropics, and we have been gathering meteorological data and carrying out research in alley cropping at the site for the past five years. The proposed pot study will be done at the University of Hawaii greenhouses at Manoa.

2. *Hypotheses and Methods*

Hypothesis 1.1. Pattern of reduction in maize growth with distance from hedgerow is correlated with light reaching crop.

Hypothesis 1.2. Shading is a sufficient explanation for crop growth reduction (versus below-ground competition)

Methods - An alley cropping experiment will be established with four treatments: 1) full alley crop with trees and maize, 2) hedgerow trees only, 3) maize only, and 4) maize shaded by artificial shade barriers. Hedgerows will be *Cassia spectabilis*. Maize growth and phenology will be monitored when grown between shade barriers and compared with maize is grown in the full alley crop. Similar yields on shaded plots and alley-cropped plots, if lower than yields on sole maize crop plots, would be strong evidence for light competition. Light competition could be quantified by amount of yield lost relative to control (maize-only) plots. The difference between yield in the shade barrier plots and the yield in the hedgerow plots would correspond to a below-ground competitive effect.

Measurements of hedgerow biomass and leaf area will be taken every two weeks. A hedgerow growth model based on changes in width, height, and biomass of hedgerows and leaf area/biomass allometries will be developed. Light interception and light partitioning between the crop and the hedgerows will be calculated based on these parameters for the hedgerow and the crop using computer models. Light intercepted multiplied by a radiation conversion efficiency will be used to model hedgerow growth.

The light competition submodel of Cropsys for hedgerow systems will be parametrized using light data and hedgerow growth data from the experiment. Cropsys will then be run with only the light competition submodel engaged as an independent test of the hypothesis that shading will account for differences in crop yield between alley cropped systems and controls.

Hypothesis 2.1. Fertilizer K is recovered to a greater extent by trees than crops, indicating severe competition (versus a lesser extent by trees than crops, which would indicate complementary resource use).

Hypothesis 2.2. Green manure K is recovered to a greater extent by trees than crops (versus a lesser extent by trees than crops).

Methods - To test whether rubidium is a suitable tracer for potassium, legume trees (*Gliricidia sepium*, *Calliandra calothyrsus*, and *Cassia siamea*) and maize plants (one of each) will be grown in the same pot with different levels of K tagged with a constant percent of Rb. Plants will be destructively harvested at different times and root, shoot, and leaf tissues sampled for Rb and K. Soil will be sampled simultaneously with harvests and analyzed for extractable Rb and K. Results will show if legume trees and maize take up Rb and K in the same proportions that the elements exist in the soil, or if there is a constant, quantifiable discrimination at different levels of K in the soil. Results will also show if the Rb/K ratio is constant

for all parts of the plant, especially leaves, and if this ratio is constant over time. If there were different Rb/K ratios at different K levels, Rb would not be a suitable tracer for K.

If rubidium is found to be a suitable tracer for potassium in the system, Rb-labeled K fertilizer will be applied to the alley in an alley crop. Hedgerow trees (the three species from the pot study above) and the maize crop will be analyzed for Rb and K and thus K taken up from labeled fertilizer will be quantified for each species. Amount of competition for potassium will be quantified based on percentage of fertilizer K taken up by the trees. Differences in treatment (tree species) will be analyzed to see if some species compete more than others for K.

In a second iteration of the experiment, green manure from trees that have been labeled with Rb will be applied to a different plot. Amount of K taken up by the crop and the hedgerows from the green manure again will be quantified by analyzing the amount of Rb in plant tissues.

2. *Timetable*

	1993	1994	1995
	JFMAMJJASOND	JFMAMJJASOND	JFMAMJJASOND
Pot study of Rb/K	X---X		
Rb/K Fertilizer study	X-----X		
Rb-labeled green manure study		X-----X	
Light comp. study:			
Growing of hedgerows	X----X		
First Crop Maize	X----X		
Second Crop Maize		X---X	
Data analysis and writing		X------X	

Environmental Impact: Alley cropping is an alternative to forest fallowing on the one hand and intensive fertilization on the other. Better understanding of the limitations and constraints of alley cropping and other agroforestry systems will allow more successful implementation in situations where they are appropriate. More widespread use of sustainable agroforestry systems will alleviate pressure to cut remaining forests and decrease environmental damage caused by overuse of chemical fertilizers. Agroforestry can contribute to more healthy watersheds and ecosystems but only through scientific understanding and sound implementation.

Budget (93-94): UH-05

	Year 1 CRSP	Matching	Total
Salaries			
Graduate Assistant[a]	13,854	6,000	19,854
Fringe (12%)	1,662	1,500	31,662
Supplies and operations[b]	2,000		2,000
Travel			
US[c]	2,000		2,000
INT[d]	5,000		5,000
Equipment	0		0
Indirect costs	10,787		10,787
SUBTOTAL	35,303	7,500	42,803

[a]Graduate assistant J. B. Friday (Ph.D., step 2).
[b]Supplies include purchase of rubidium.
[c]Travel is for interisland trips to Kauai.
[d]International travel is for a trip to upland rice consortium research sites.

Human Resource Commitments (FTE):

University of Hawaii

Senior Scientist	0.2
Junior Scientist	0.5
TOTAL	0.7

SOIL MANAGEMENT CRSP
ANNUAL ACTIVITY WORK PLAN AND BUDGET REQUEST

Fiscal Year: 1993-1994

Project Number: PDSS-01

Title: Phosphorus Decision Support System (PDSS)

Global Thrust: Sustainable Agriculture

Constraints Addressed: Food production in many tropical countries remains low and sporadic because of phosphorus deficiencies in the soil. Much of this condition is a result of insufficient information being given to key managers. In many regions phosphorus soil tests have not been calibrated for all combinations of crops and soils, or are funds likely to be available for such calibrations in the foreseeable future. These regions usually have certain similarities to other regions, however, such that with expert knowledge reasonable recommendations for solutions to soil problems can be made. The goal of the phosphorus decision support system described here is to provide this expert knowledge. In other regions where soil test technology has already been adopted, the effects of soil particle size and clay mineralogy are not being considered in soil test interpretations or in making recommendations. Evidence from regions with extensive experience and research in phosphorus management suggests that it is important to consider these factors.

Principal Investigators and Institutions:

Russell Yost - University of Hawaii, General responsibility for overall progress on the project. A major activity is the crafting of the knowledge for representation in the knowledge base PDSS.

Fred Cox - North Carolina State University, Dr. Cox has modeled phosphorus reactions of particular relevance to P fertilization of crops in acid, high P sorbing soils. He continues to research the ability to predict P buffer coefficients as affected by variables that are proxies for surface area and sorption intensity. Studies conducted by one of his students (Dr. I. Lins) serve as one of the cornerstones of the P sorption modeling work adopted for PDSS.

Shaw Reid - Cornell University, Dr. Reid has experience in software development and critiquing the design and presentation of agricultural software. His primary role is to evaluate the PDSS software and make suggestions to enhance its user-friendliness and practical adaptation.

Art Onken - Texas A&M University, Dr. Onken, who has experience with practical agricultural management of P in soils of West Texas as well as those in Mali and Niger, critiques the knowledge and approach adopted by PDSS. He also is the liaison between the development team and the TropSoils Niger/Mali work on soil phosphorus management.

Collaborators and Institutions:

Ibere Lins - Campo Grande, Mato Grosso do Sul, Brazil
Puntipa Vichiensanth - Khon Kaen University, Khon Kaen, Thailand
B.T. Kang - International Institute for Tropical Agriculture, Ibadan, Nigeria
I. Putu Gedjer Widjaja-adhi - Centre for Soils and Agroclimate Research, Bogor, Indonesia
A. Bationo - IFDC/ICRISAT, Niger
Jose Espinosa - Potash and Phosphate Institute, Costa Rica
Patrick Jomini - Switzerland
Andrew Sharpley - USDA-ARS
Deborah Hellums - IFDC
Stephen Itoga - University of Hawaii
John Li - University of Hawaii
Martinus Pandutama (Indonesia) - University of Hawaii

Objectives: The primary goal of this project is to develop the Phosphorus Decision Support System that will implement the best diagnostic and predictive methodology in a form useable by those with little formal training but with great responsibility for planning and executing agricultural development.

We propose to achieve this objective by developing the Phosphorus Decision Support System software and documentation that will use observations and previous cropping history as well as soil and plant analysis to diagnose P deficiencies and to make economically viable fertilizer predictions.

Progress Report: The PDSS project seeks to develop a diagnostic and prescriptive methodology to aid in solving phosphorus management problems. Typical phosphorus management problems are those associated with inadequate phosphorus for crop production (undetected P deficiency) and over-application of phosphate fertilizers and phosphate-containing organic manures.

The PDSS project has continued to search for experiential information that would be useful in identifying potential P deficiencies. We have gathered a variety of information and clues that are used by experts and have attempted to rank them in terms of their reliability in diagnosing P deficiency. One example is the presence of indicator plants that are typically associated with P-deficient soils. The presence of such indicator plants is represented on a scale of 0 to 1, with 0.5 indicating indifference as to whether the indicator plant implies or suggests the possibility of P deficiency. The various suggestive pieces of evidence (such as soil order, previous crop yields, indicator plants) are combined with the more reliable information such as plant and soil analysis to arrive at a combined estimate of the probability of P deficiency. The various lines of evidence—some rather subjective and some quite quantitative—are combined using Bayesian methods of conditional probability. The final combined probability also ranges from 0 to 1 with 0.5 indicating complete indifference as to whether there is P deficiency.

Efforts also continue in obtaining estimates of P buffer coefficients and tabulating the various estimates to aid in comparison and in developing a database of coefficients and associated soil properties thought to be important in predicting buffer coefficients.

Preliminary results in the prediction of P buffer coefficients by soil texture by Fred Cox seem favorable—excellent predictions were obtained based on the theory that the surface area and surface sorption intensity are the critical mechanisms of P sorption. Further work is under way by Dr. Cox and his post-doc research associate from Brazil, Dr. Aquino. Dr. Aquino is attempting to improve the predictability of buffer coefficients by including measures of the AL and Fe content (possible factors quantifying the soil sorption intensity) together with the quantity of clay (a proxy variable for surface sorption areas used in earlier work by Dr. Cox.

Buffer coefficients are being determined for a range of soils in Hawaii by two students (one of whom is supported by TropSoils) in hopes of using modern X-ray analysis techniques such as the Rietveld refinement of quantifying clay type and quantity. Improved estimates and clay type and quantity are seen as basic information that will help improve prediction of the number of hydroxyl sites the soil might have available for P sorption.

The project has several software developments under way. One is to locate diagnostic slides of P deficiency—including the absence of symptoms—for inclusion in the PDSS (Phosphorus Decision Support System) computer program. These slides are being digitized for use as examples of P deficiency symptoms.

Another part of the PDSS work is the development of an economic analysis framework that considers the residual value of the applied phosphorus. This economic analysis module will be a dynamic modeling approach developed and described by P. Jomini, Purdue University, during his thesis work in Niger. This work is approximately 50% complete. The dynamic programming code has been re-written as a module that can be executed by the PDSS main program when economic analysis is desired.

Professional Contributions:

Presentations at the 1991 American Society of Agronomy meetings and at the Western Regional Phosphate Work Group.

Additional Funding and Support Received for Project.

Funds to support complementary objectives have been obtained from the State of Hawaii and from the USDA Section 406 Program.

Training Activities:

A. Graduate student thesis completed: none.

B. Graduate student thesis work in progress

Name	Degree	Funding	Thesis Title
James Jackman	M.S.	Local	Predicting phosphorus buffer coefficients for soils of Hawaii based on sorption area and intensity.
Fengmao Guo	M.S.	TropSoils	Predicting the residual available phosphorus based on soil sorption area and sorption intensity.
Xinmin Wang	Ph.D.	USDA 406	To be determined but likely related to prediction of the conversion of unavailable P to available P during P desorption.
Mengbo Li	Ph.D.	USDA Hatch	Combined nitrogen and phosphorus management for decision aid designed for the State of Hawaii
Martinus Pandutama	Ph.D.	East West Center	To be determined. Likely related to availability in several Indonesian ecosystems.

Work Planned for Next Year:

Overview. During 1993-1994, the beta release of the PDSS program will be completed and extensive testing will begin. Preliminary evaluation will begin in Southeast Asia with our collaborators in Philippines, Indonesia, and Thailand. The only major module remaining to be implemented is economic analysis, which is under discussion with Dr. Patrick Jomini, formerly of the TSMM project in Niger, Africa.

Other knowledge modules under consideration include those relating to prediction of sustainability of P, and prediction of P in runoff and percolate. Version 1 of PDSS was expected to be completed before October 1993.

Specific Activities

1. **PDSS Evaluation:** Prototype copies of PDSS will be demonstrated to collaborators beginning in June 1993 in the Philippines, Indonesia, and Thailand. On-site demonstrations and evaluations will be conducted with collaborators: George, Cassman, Kirk (IRRI), Garrity (ICRAF), Mamaril, Valentin (IRRI-Indonesia), Amien, Gedjer, Syarifuddin (CSAR-Bogor). Copies of the prototype and evaluation questionnaire will be sent to collaborators Vichensanth, Vityakon, and Panchiban at Khon Kaen University, and Rerkasem, (Chiang Mai University) Thailand.

   Dr. T. Dierolf will also begin demonstrations of PDSS with the ADSS work under way (ADSS-01).

   We hope also to begin evaluation of the program in Central America (University of San Jose, Costa Rica), South America (International Potash and Phosphate Institute, Dr. Espinosa), Mali and Niger (via Texas A&M scientists), and through IFDC (International Fertilizer Development Center) staff in Togo and Niger.

   These various evaluations will provide some of the feedback that will drive the final development and modification to best fit users' needs.
2. **Economic Analysis:** The economic analysis approach is being developed by Dr. Patrick Jomini, formerly of the TSMM project in Niger, Africa. Dr. Jomini's formulation of the model, a dynamic modeling approach, is being considered along with other candidate approaches such as multiple goal programming. It is anticipated that the economic model decision will be determined and the model coded for implementation before September 1993.
3. **Other Modules:** Other knowledge modules under consideration include those relating to prediction of residual P sustainability based on a specified cropping system, P application rate, soil properties (both buffering capacity and residual available P). Also being considered is a module that incorporates more extensive knowledge related to prediction of environmentally degrading P concentrations in runoff and percolate from soils. Incorporation of these modules is limited by the objective of completing an initial release copy of PDSS before October

Research Sites:

Budget (93-94): PDSS-01

Object	CRSP	Total Funding Source External	Matching	Host	Total
Salaries	65000	70000	16490	10000	161490
Fringe Benefits	11700	7000	4500	1000	24200
Allowances	0	0	0	0	0
Consulting	0	0	0	0	0
Travel, US	3000	0	0	0	3000
Travel, INT	4000	0	0	0	4000
Supplies	2000	0	2000	0	4000
Equipment	2500	0	5000	0	7500
Communications	1000	200	1000	100	2300
Shipping/freight	0	0	0	0	0
Other	1000	0	0	0	1000
Direct costs	90200	77200	28990	11100	207490
Indirect costs	38590	0	0	0	38590
Total	128790	77200	28990	11100	246080

Special Budget Requirements: None.

Human Resource Commitments:

Institutions	Senior	Full Time Equivalents (FTE) Junior	Tech.	Adm. Support	Other	Total
US	1.20	.5				1.70
Host	1.00					1.00
Other	.75					.75
Total	2.95	.5				3.45

Narrative Explanation of Human Resources: Five graduate students are involved in different aspects of the development, calibration and validation of the PDSS. Three are supported from non-CRSP funds. Dr. John Li coordinates the programming of PDSS in consultation with Yost and Dr. Stephen Itoga of the Information and Computer Science Department. Yost coordinates PDSS development with CoxReidand Onken and its application and testing with identified collaborators.

Date Initiated: 1987

Expected Completion: September 1994

Signatures:

Principal Investigator	Date	Program Coordinator	Date

If signatures are not available, attach a letter or other document that indicates that this project is a cooperative effort.

SOIL MANAGEMENT CRSP
ANNUAL ACTIVITY WORK PLAN AND BUDGET REQUEST

Fiscal Year: 1993-1994

Project Number: ADSS-01

Title: Acidity Decision Support System (ADSS)

Global Thrust: Sustainable Agriculture

Constraints Addressed: Nutrient losses and deficiencies

Principal Investigators and Institutions:
Russell Yost - University of Hawaii
Thomas Dierolf - Padang, Indonesia
Both are responsible for the overall project program.

Collaborators and Institutions:
Le Istiqlal Amien - Bogor, Indonesia
John Li - University of Hawaii
Phoebe Kilham - University of Hawaii
Tengah, Abdullah, MARDI, Malaysia
Bruce Trangmar, Canterbury, New Zealand
Jot Smyth, North Carolina State University

Objectives:
1. Use ADSS in combination with a GIS to evaluate the cost-effectiveness of liming on soybean production for a selected test area in Indonesia.
2. Establish two-way interactions with current and potential users of ADSS to both identify and address their needs and to obtain feedback from them on ways to improve the utility of ADSS.
3. Obtain historical research data to test and improve the predictive capability of ADSS. This includes both unpublished data from the TropSoils Project in Indonesia and published data from TropSoils Projects at other universities—particularly the North Carolina State University work conducted on soils in Manaus, Brazil (Smyth and Cravo, 1991).
4. Revise and improve the economic analysis of lime residual effects in ADSS with the aid of TSMM scientists.

Progress Report: This project has only become effective as of March 1993, with the graduation and return to Indonesia of Dr. Tom Dierolf. Within this short period of time the following progress has been achieved.
1. After consultation with the CSAR, Bogor, collaborators the ADSS and GIS linkage will be pursued with the site data collected and processed by Dr. Bruce Trangmar, and Ms. Deborah Paulsen and Phoebe Kilham. This site is appropriate

because more information probably exists for this site than for many in Sumatra. We will be exploring this linkage during Yost's trip to Indonesia in late May 1993.

2. Initial discussions with user groups identified by the CSAR, Bogor, have begun and a demonstration system has been identified and established.
3. Dr. Smyth, North Carolina State University, has agreed to collaborate with us to update the ADSS algorithms to include recent research on lime and cation movement in Manaus, Brazil.

Work Planned for Next Year: During the next year we will:

1. Develop a case study in Sitiung linking the ADSS module with a geographic information system that will display the results of the lime recommendations generated from the ADSS module. Dierolf and Amien.
2. Prepare an tutorial diskette on ADSS that can be used to introduce the concepts and methods of ADSS. Dierolf, Yost and Amien.
3. Develop a tutorial on how to adapt ADSS for local soil databases, how to develop and adapt soil data for linkage with ADSS. Yost, Li and Dierolf.
4. Prepare an interim report describing the validation of ADSS and suggestions for improvement and modification of the knowledgebase. Dierolf and Amien.

Most of the work described above will be completed by Dr. Tom Dierolf in close collaboration with Dr. A. Istiqlal and the CSAR staff; other portions of the work, particularly modification of ADSS and some of the ADSS-GIS linkage work, will be done in Hawaii.

Research Sites: Indonesia, Malaysia, and Hawaii

Budget (93-94): ADSS-01

Object	CRSP	Total Funding Source External	Matching	Host	Total
Salaries	10800	7500	3500	5000	26800
Fringe Benefits	2240		750	1000	3990
Allowances					
Consulting	5000				5000
Travel, US	0				0
Travel, INT	5000				5000
Supplies	1000		500		1500
Equipment	0				
Communications	500	100	100	100	800
Shipping/Freight	0				
Other	500				500
Direct costs	25040	7600	4850	6100	43590
Indirect Costs	7512				7512
Total	32552	7600	4850	6100	51102

Special Budget Requirements: None

Human Resource Commitments:

Institutions	Senior	Junior	Full Time Equivalents (FTE) Tech.	Adm. Support	Other	Total
US	.45	.5		0.0		.95
Host	.75		1.0	.25		2.0
Other						
Total	1.20	.5	1.0	.25		2.95

Narrative Explanation of Human Resources: Dr. Thomas Dierolf serves as a consulting scientist in the application and calibration of ADSS in Indonesia. He is coordinating his effort in concert with the Center for Soil and Agroclimate Research in Bogor. His principal contacts are Dr. Istiqlal Amien and Dr. Syarfuddin Karama. The former is a UH graduate student who translated the early version of ADSS into Bahasa Indonesia. Technical support is provided by Yost and Li.

Date Initiated: 1992

Expected Completion: 1994

Signatures:

Principal Investigator	Date	Program Coordinator	Date

If signatures are not available, attach a letter or other document that indicates that this project is a cooperative effort.

SOIL MANAGEMENT CRSP
ANNUAL ACTIVITY WORK PLAN AND BUDGET REQUEST

Fiscal Year: 1993-1994

Project Number: CU-04a

Title: Effects of the Soil Chemical Properties on Structural Stability of Soil Aggregates in the Tropics

Global Thrust: Sustainable Agriculture, Soil Physical Limitations

Constraints Addressed: Factors determining physical stability of aggregates in soils of the tropics.

Principal Investigators and Institutions:
Murray McBride - Cornell University
Eugenio Marcano-Martinez - Cornell University

Collaborators and Institutions:
Elemer Bornemisza - Costa Rican advisor. Centro de Investigacions agronomicas, Universidad de Costa Rica.

Objectives:
1. Identify the mineral components of oxidic soils that are most highly dispersible;
2. Characterize the surface charge properties of the soils as well as their mineral components;
3. Observe the effects of amendments on the charge properties and dispersibility of these soils;
4. Develop a physical-chemical model of aggregate stability; and
5. Establish recommendations for maintaining soil structural stability.

Progress Report: Samples of an Oxisol from Manaus, Brazil, subjected to different crop rotation systems and lime applications were studied to assess the influence of organic matter incorporation, time of cultivation, and liming on the stability of the clay fraction by measuring water dispersible clay and electrophoretic mobility (or zeta potential) of the colloidal phase. There was a slight increase in pH (about 0.5 pH units) in the limed soils; nevertheless, this change was not reflected in measurements of clay dispersibility or in the zeta potential of the dispersed phase in suspension. After the flocculated phase was separated and dispersed using a sonic disrupter, the resuspended clays had an average zeta potential slightly higher than the original water dispersible clay. There were no apparent effects from crop rotation or lime applications on the characteristics of the flocculated clays.

Work Planned for Next Year: Remaining experiments will be carried out in the Soil Chemistry Laboratory at Cornell University by the principal investigators.

Studies similar to those conducted with the Brazilian Oxisols will be carried out with the soils collected from Costa Rica. Later, different chemical treatments will be applied to the soils under controlled laboratory conditions to study in more detail the effects of these treatments on the surface charge of the colloidal fraction. Soil aggregates separated from the soils will be subjected to immersion in different solutions to test some of the results from the previous experiments. Following is the calendar of activities scheduled from June 1993 to June 1994:

CALENDAR OF EVENTS

EVENT	DATE
Finish study of the effects of cultivation on colloidal stability of Costa Rican Ultisols and analyze the results.	June 1993 - August 1993
Begin application of chemical treatments in the laboratory to different soils. Measure charge variation and dispersibility. Prepare poster to be presented at annual Agronomy Society meeting.	September 1993 - November 1993
Continue study of effects of chemical treatments on clay stability. Start studies on aggregates stability.	December 1993 - February 1994
Finish studies on aggregate stability. Confirm some results with model systems (pure or well-defined minerals). Analyze the results. Prepare papers.	March 1994 - May 1994

Research Site: Soil Chemistry Laboratory, Cornell University

BUDGET (93- 94): CU-04a

OBJECT	TOTAL FUNDING SOURCE CRSP	EXTERNAL	MATCHING	HOST	TOTAL
Salaries					
GRA (1.0) Stipend	13,475				13,475
GRA (1.0) Fees	4,468				4,468
M. McBride (10%)				6,276	6,276
Administrative Support	500				500
Fringe Benefits @28.97%	145				
Matching F.B. @ 36.78%				2,308	2,308
Allowances (GRA & PI)*	2,000				2,000
Visiting Scientist					0
Consulting					
Travel					
US	800				800
International					0
Supplies	2,000				2,000
Equipment	2,500				2,500
Equipment Maintenance					0
Telecommunication and Copying	500				500
Analytical Costs	1,000				1,000
Publication	500				
Labor (off-campus)*					
TOTAL DIRECT COSTS	27,888			8,584	36,472
Indirect Costs					
On-Campus	10,028			4,550	14,577
Off-Campus (* = Off-Campus)	600				600
TOTAL PROJECT COSTS	38,515			13,134	51,650

INSTITUTION	FULL TIME EQUIVALENTS (FTE) SCIENTIST SENIOR	JUNIOR	TECHNICIAN	ADM. SUPPORT	OTHER	TOTAL
US	0.10	1.00	0.04			1.14
HOST	0.25					0.25
OTHER						0.00
TOTAL	0.35	1.00	0.04			1.39

Date Initiated:

Expected Completion: September 24, 1995

SOIL MANAGEMENT CRSP
ANNUAL ACTIVITY WORK PLAN AND BUDGET REQUEST

Fiscal Year: 1993-1994

Project Number: TAMU-02

Title: Soil and Water Management and Conservation for Sustainable Agriculture

Global Thrust: Sustainable Agriculture

Constraints Addressed: Water stress, nutrient deficiencies and losses, soil physical limitations, topographic limitations.

Principal Investigators and Institutions:
A.S.R. Juo - TAES, Texas A&M University
C.W. Wendt - TAES, Texas A&M University

Objectives: The overall goal of this project is to conduct research pertaining to the development of soil and water management practices for sustainable food, fodder and fiber production under semi-arid conditions. Presently, this project consists of four sub-projects:

TAMU-02-A	Tillage and Residue Effects on Water Extraction, Rooting Depth, Growth and Yield of Dryland Sorghum
TAMU-02-B	Structural Dynamics of Volcanic Soils Under Intensive Cultivation
TAMU-02-C	Long-term Effects of Crop Residue, Green Manure, and Tillage on Crop Yields and Soil Productivity in Mali
TAMU-02-D	The Estimation of the Soil Water Balance Under Sahelian Conditions

Participating collaborators, specific objectives, progress reports, planned activities and proposed budgets are provided under each subproject.

Budget (93-94): TAMU-02

Object	CRSP	External	Matching	Host	Total
Salaries	38,064.63	0.00	16,519.00		54,583.63
Fringe benefits	12,211.52	0.00	4,661.00		16,872.52
Allowances	0.00	0.00		3,000.00	3,000.00
Consulting	0.00	0.00			0.00
Travel, US	1,438.94	0.00			1,438.94
Travel, INT	11,377.88	0.00			11,377.88
Supplies	13,658.41	0.00			13,658.41
Equipment	4,752.00	0.00			4,752.00
Communications	1,458.94	0.00			1,458.94
Shipping/Freight	1,500.00	0.00			1,500.00
Publications	1,719.47	0.00			1,719.47
Other direct costs	4,000.00	0.00			4,000.00
Indirect costs	30,938.82	0.00	9,107.40		40,046.22
TOTAL	121,120.61	0.00	30,287.40	3,000.00	154,408.01

Human Resource Commitments:

	Full Time Equivalents (FTE)					
Institution	Senior Scientist	Junior Scientist	Technician	Admin. Support	Other	Total
US	0.36	1.00	0.25	0.25		1.86
Host	0.10	0.85	1.00	0.20		2.15
Other	0.15					0.15
Total	0.61	1.85	1.25	0.45	0.00	4.16

Date Initiated: November 1, 1990

Expected Completion: September 24, 1994

Signatures:

Project Leader _____ Date _____ Program Coordinator _____ Date _____

TAMU-02 DESCRIPTION OF SUBPROJECTS

Subproject Number: TAMU-02-A

Title: Tillage and Residue Effects on Water Extraction, Rooting Depth, Growth and Yield of Dryland Sorghum

Collaborators and Institutions:

Abdoul A. Sow - Institut d'Economie Rurale, Mali (currently a Ph.D. student at Texas A&M University)
Lloyd R. Hossner - TAES, Texas A&M University
P. Unger - USDA-ARS, Bushland, TX
B. Stewart - USDA-ARS, Bushland, TX

Objectives: In many areas of the semiarid zone, there is not enough precipitation during the growing season to meet a crop's water demand. Efficient water use is absolutely essential for dryland crop production. The objectives of this study are to:

1. Determine the influence of crop residue and tillage on rooting depth, the redistribution of water through the soil profile, and growth and yield of sorghum; and
2. Quantify and compare water loss by runoff from residue and tillage fields.

Progress Report: Field work was completed at the research site in Bushland, TX. The effects of furrow diking and residue management on water extraction, runoff, rooting depth, growth and yield of grain sorghum on gently sloping land were evaluated.

Diking and no-tillage with residue treatments reduced runoff and significantly increased net water use. Grain yield of no-tilled sorghum with residue averaged 4,950 kg ha^{-1} or about 66, 4 and 22% higher than the diked, undiked and no-tillage without residue treatments, respectively. Rooting was significantly deeper with no-tillage treatments than with diked and undiked treatments at 30 and 60 days after planting.

Work Planned for Next Year:

CALENDAR OF EVENTS

EVENT	DATE
Complete soil and plant analyses for nitrogen and other nutrients. Statistical analysis of data from the 1991 and 1992 growing seasons.	Present - December 1993
Analyze data from research results collected in 1991 and 1992.	January - May 1994
Write research report, prepare papers for publication	June - September 1994

Research Site: Bushland, Texas

Budget (93-94): TAMU-02-A

Object	CRSP	External	Matching	Host	Total
Salaries	13,565.10	0.00	4,325.00		17,890.10
Fringe benefits	4,363.50	0.00	1,220.00		5,583.50
Allowances	0.00	0.00			0.00
Consulting	0.00	0.00			0.00
Travel, US	607.94	0.00			607.94
Travel, INT	215.88	0.00			215.88
Supplies	2,161.91	0.00			2,161.91
Equipment	0.00	0.00			0.00
Communications	207.94	0.00			207.94
Shipping/Freight	0.00	0.00			0.00
Publications	1,053.97	0.00			1,053.97
Other direct costs	0.00	0.00			0.00
Indirect costs	9,535.77	0.00	2,384.35		11,920.12
TOTAL	31,712.01	0.00	7,929.35	0.00	39,641.36

Subproject Number: TAMU-02-B

Title: Structural Dynamics of Volcanic Soils Under Intensive Cultivation

Collaborators and Institutions:

Carlos Cervantes - National University, Heredia, Costa Rica
Robert Schwartz - TAES, Texas A&M University
Francisco Cervantes - Ministry of Agriculture, Costa Rica
A.S.R. Juo - TAES, Texas A&M University
Lawrence P. Wilding - TAES, Texas A&M University
Kevin McInnes - TAES, Texas A&M University
Thomas Thurow - TAES, Texas A&M University

Carlos Cervantes and A.S.R. Juo are the responsible investigators. R. Schwartz, Graduate Research Assistant at TAMU is responsible for conducting the research pertaining to soil structure in Costa Rica. F. Cervantes provides in-country support in the Catago area. L. Wilding provides technical backstopping related to soil structure. K. McInnes provides technical backstopping related to soil water flow. T. Thurow provides technical backstopping related to soil erosion and runoff.

Objectives: Soils derived from volcanic materials often are intensively cultivated for food and cash crops in Central America. These soils play an important role in the economy and agriculture of the region because of their extensive occurrence and relative high productivity. In Costa Rica, intensive food and horticultural crop cultivation are increasingly being shifted to volcanic soils on sloping lands. While most of the young volcanic soils are predominantly cultivated using animal traction, mechanized land preparation recently has been introduced and has resulted in severe soil erosion in some cases. Young volcanic soils often are excessively prepared, although such intense cultivation may not be required on these well-drained soils. The more mature (desilicated) volcanic soils often exhibit high nutrient losses through leaching (especially N and K) under high rainfall conditions.

To address some of these concerns, the National University at Heredia in collaboration with the Ministry of Agriculture initiated several long-term on-farm soil and water conservation and nutrient cycling studies in Costa Rica to develop alternative soil management practices and cropping systems and to create public awareness of the importance of sustainable soil management. A major obstacle toward identifying appropriate soil management practices in volcanic soils is the lack of a realistic model that characterizes the physical condition and processes as a function of soil structure. Unlike for many soils, particle size distribution has limited usefulness in predicting the soil properties of most volcanic soils. Another difficulty associated with volcanic soils is the apparent change in nature and amount of surface exposed as the soil dries.

This proposed study is in response to an invitation from the Universidad Nacional at Heredia to conduct specific research that would complement the on-going long-term research identified above. The major purpose of this study is to quantify the physical structure of volcanic soils, assess the dynamics of these systems in response to

selected management systems, and to predict soil hydraulic properties from quantitative descriptions of soil structure. An adjunct study to be jointly executed and funded by Costa Rican collaborators and SM-CRSP is also proposed. The purpose of the this study is to quantify soil loss, runoff and nutrient losses associated with runoff on established runoff plots. The specific objectives of these studies are to:

1. Quantify soil loss, runoff and nutrient losses associated with runoff;
2. Quantify the physical structure of volcanic soils and assess the dynamics of these systems in response to selected management systems;
3. Evaluate the ability of quantitative descriptions of soil structure to predict soil hydraulic properties; and
4. Evaluate and recommend suitable tillage and nutrient management practices.

Progress Report: Communication between the Universidad Nacional, Heredia, Costa Rica and TropSoils/TAMU was initiated in January, 1993 regarding a mutual interest in starting a collaborative project to complement ongoing and proposed (funding from IICA) research studies in Costa Rica. The correspondence was followed by a site visit by A.S.R. Juo to the Universidad Nacional, Heredia, Costa Rica to discuss research collaboration within the framework of the on-going TAMU/TropSoils project on steepland soil degradation and rejuvenation. A.S.R. Juo also visited three potential research sites (Catago, Pejibaye and Purescal) where the University has ongoing studies.

Work Planned for Next Year:

CALENDAR OF EVENTS

EVENT	DATE
Elaborate on research plan in collaboration with the Universidad Nacional (Carlos Cervantes and R. Schwartz with input from Principal Investigators and Collaborators). Visit site in November/December (A. Juo and R. Schwartz) to select research sites and collect preliminary soil samples. The soil samples are needed to determine which field and laboratory methods are suitable for these soils.	Present - December 1993
Complete detailed research plan by March 1994 (Carlos Cervantes and R. Schwartz with input from Principal Investigators and Collaborators). Obtain all required instrumentation by March 1994 (R. Schwartz).	January - March 1994

CALENDAR OF EVENTS (continued)

EVENT	DATE
Conduct research in Costa Rica (R. Schwartz, approx. 2 months). Collect soil samples for subsequent analysis, collect resin-impregnated soil blocks, and measure soil hydraulic properties. Measurements to be completed regarding objective (1) above will be completed by personnel of the Universidad Nacional. The calendar of operations to be carried out under objective (1) have yet to be delineated.	April - June 1994
Prepare and analyze samples in the laborabory at TAMU (R. Schwartz). Major analyses are: (1) macroporosity using image analysis of photographs taken from fluorescent resin-impregnated soil blocks; (2) water retention measurements to characterize void size distribution; (3) aggregate size distribution and aggregate stability and (4) surface charge.	July - September 1994

Research Sites: Catago, Costa Rica, Pejibaye, Costa Rica

Budget (93-94): TAMU-02-B

Object	CRSP	External	Matching	Host[a]	Total
Salaries	14,406.81	0.00	6,372.00		20,778.81
Fringe benefits	4,827.90	0.00	1,798.00		6,625.90
Allowances	0.00	0.00		3,000.00	3,000.00
Consulting	0.00	0.00			0.00
Travel, US	665.99	0.00			665.99
Travel, INT	3,831.97	0.00			3,831.97
Supplies	3,248.98	0.00			3,248.98
Equipment[b]	4,752.00	0.00			4,752.00
Communications	285.99	0.00			285.99
Shipping/Freight	1,500.00	0.00			1,500.00
Publications	582.99	0.00			582.99
Other direct costs	0.00	0.00			0.00
Indirect costs	12,620.77	0.00	3,513.10		16,133.87
TOTAL	46,723.40	0.00	11,683.10	3,000.00	61,406.50

[a]Host contributions shown include estimated housing costs. The National University and the Ministry of Agriculture, Costa Rica will also be responsible for the installation of USLE plots, local transportation, labor and field supplies, and soil analysis in Costa Rica.
[b]Proposed instrumentation to be funded by SM-CRSP includes a tension infiltrometer and a tipping bucket rain gage.

Subproject Number: TAMU-02-C

Title: Long-term Effects of Crop Residue, Green Manure and Tillage on Crop Yields and Soil Productivity in Mali

Collaborators and Institutions:

Zoumana Kouyate - Institut d'Economie Rurale, Cinzana Station, Mali
Samba Traore - Institut d'Economie Rurale, Cinzana Station, Mali
A.S.R. Juo - TAES, Texas A&M University
C.W. Wendt - TAES, Texas A&M University
Robert J. Lascano - TAES, Texas A&M University
Arthur B. Onken - TAES, Texas A&M University
Lloyd R. Hossner - TAES, Texas A&M University

Zoumana Kouyate, A.S.R. Juo and C. Wendt are the responsible investigators. S. Traore is Director of the Cinzana Experiment Station and oversees research activities at the station. R. Lascano, A. Onken and Lloyd Hossner provide technical backstopping.

Objectives: The decline of soil fertility is a major factor limiting crop growth and yield under traditional farming practices in Mali. Moreover, purchased inputs such as fertilizers and lime are beyond the financial reach of most food crop farmers. Consequently there is an urgent need to develop alternative low-input soil and crop management systems to sustain the increasing food need in the country. Field studies dealing with long-term effects of soil and crop management practices on soil productivity under the Sahelian environment are scanty. Such knowledge and information are essential for developing sustainable farming systems in Mali and in the Sahel region as a whole. The objectives of this study are to:

1. Study the long-term interactive effects of soil tillage, crop residue and green manure on soil fertility and crop yields; and
2. Study the effects of organic inputs on soil chemical and physical properties.

Progress Report: Results from the field data for the first year (1991) are contained in the annual report submitted by IER to TropSoils/TAMU and summarized in the SM-CRSP annual progress report. Results from the 1992 season are to be submitted in June, 1993. Results obtained to date do not show any significant differences between grain sorghum yield obtained in simple rotation cowpea/sorghum and sorghum after legume crops (*Sesbania* and *Dolichos* spp.) incorporated as green manure. The restoration of the first sorghum crop "residue in sorghum/sorghum rotation" had a significant effect with tied ridges on the second or following sorghum crop yield. The increases of sorghum grain yield by tied ridges were 57% on poor soil and 31% on rich soil.

Miscellaneous Report Published:

Kouyate, Z. and C. Wendt. Soil water efficiency of sorghum and cowpea as affected by nutrient input and tillage, TropSoils Bulletin Number 92-01, Soil Management Collaborative Research Support Program, North Carolina State University, Raleigh, 1992.

Work Planned for Next Year:

CALENDAR OF EVENTS

EVENT	DATE
Soil preparation and planting (July) Legume crop incorporation as green manure (October) Harvesting of sorghum crop (November)	Present - December 1993
Analysis of all data of 1993 growing season for progress report. Progress report will be submitted in May/June.	January - April 1993
Preparation of input to be utilized in the field (May). Soil preparation and planting (July). Soil sampling (August). Measurements, weeding, etc.	May - September 1994

Research Site: Cinzana IER Research Station, Mali

Budget (93-94): TAMU-02-C

Object	CRSP	External	Matching	Host[a]	Total
Salaries	7,983.01	0.00	4,846.00		12,829.01
Fringe benefits	2,794.07	0.00	1,367.00		4,161.07
Allowances	0.00	0.00			0.00
Consulting	0.00	0.00			0.00
Travel, US	136.76	0.00			136.76
Travel, INT	5,773.52	0.00			5,773.52
Supplies	6,705.14	0.00			6,705.14
Equipment	0.00	0.00			0.00
Communications	636.76	0.00			636.76
Shipping/Freight	0.00	0.00			0.00
Publications	68.38	0.00			68.38
Other direct costs[b]	4,000.00	0.00			4,000.00
Indirect costs	7,435.98	0.00	2,671.59		10,107.57
TOTAL	35,533.62	0.00	8,884.59	0.00	44,418.21

[a]Project personnel of IER indicate that it is difficult to estimate the monetary value and human resource commitments provided by IER. However, the support provided by IER in connection with this subproject is substantial and includes staff salaries, office and work facilities, animal traction, laboratory services, obligations for equipment and some vehicle maintenance.
[b]Other direct costs are vehicle maintenance ($2,000) and field labor ($2,000).

Project Number: TAMU-02-D

Title: The Estimation of the Soil Water Balance Under Sahelian

Collaborators and Institutions:

Mohamadou Gandah - INRAN, Niger
William A. Payne - ICRISAT Sahelian Center, Niger
Robert J. Lascano - TAES, Texas A&M University
Charles W. Wendt - TAES, Texas A&M University

M. Gandah is the responsible investigator. W. Payne, millet physiologist of ICRISAT, is a principal collaborator in Niger and will work on the physiological aspects and analysis of climatic data. R. Lascano and C. Wendt provide technical backstopping related to the use of ENWATBAL model.

Objectives:

1. Evaluate the ENWATBAL model for simulating the water balance under rainfed conditions in the Sahel.

Progress Report: During the summer of 1992, an experiment of soil moisture balance was conducted at the Hamdallaye IMAW site in Niger. The objective of this study was to evaluate the ENWATBAL model for simulating the water balance under rainfed conditions in the Sahel.

Eight plots of 100 m^2 each and instrumented with neutron probe access tubes to a depth of 270 cm were planted to millet. Four of the plots were fertilized as recommended by INRAN and the other four plots were not fertilized. Soil moisture was measured weekly by gravimetric sampling and probe readings. Daily weather data were also recorded.

Plant data, soil moisture from neutron probe readings, evapotranspiration and bare soil evaporation after harvesting were analyzed. With a rainfall of about 592 mm from planting to harvest, no statistically different yields (grain and total dry matter) were observed between fertilized and unfertilized plots. Evapotranspiration of the crop was high for millet in the two treatments (490-570 mm), but drainage has not been accounted for. A more detailed analysis will be performed using a maximum rooting depth of 150 cm. Bare soil evaporation plus drainage after harvest for a period of 60 days has given 45-56 mm in the plots (measured to a depth of 270 cm). There was no difference in the evaporation and drainage of the residual soil moisture between the fertilized and unfertilized plots.

The data from the gravimetric soil sampling, the soil properties and weather data needed for ENWATBAL will be analyzed in June 1993 to provide a comparison of the three methods used. Some of the gaps in thee weather data (due to equipment failure) will be filled using a neighboring station and the calibration curve for the probe used will be finalized.

Work Planned for Next Year: The study conducted in 1992 will be repeated in 1993 to obtain data for drier soil moisture conditions. In mid-June, the eight millet plots will be planted. A recording weather station will be installed and data collected regularly from planting to harvest. Soil moisture data will be measured at one-week intervals using a neutron probe. Plant growth data (leaf area index, growth stage, weeding and thinning stages, harvest dates and yields) will be also be measured. ICRISAT will provide the weather station and a technician for collecting weather data. INRAN (M. Gandah) will be responsible for supervising all field operations and for analysis of the data in collaboration with W. Payne. An additional study on a plant growth model will be linked to the ENWATBAL study as local funds permit.

Research Sites: Hamdallaye, Niger

Budget (93-94): TAMU-02-D The Estimation of the Soil Water Balance Under Sahelian Conditions.

Object	CRSP	External[a]	Matching	Host[a]	Total
Salaries	2,109.71	0.00	976.00		3,085.71
Fringe benefits	226.05	0.00	276.00		502.05
Allowances	0.00	0.00		0.00	0.00
Consulting	0.00	0.00			0.00
Travel, US	28.26	0.00			28.26
Travel, INT	1,556.51	0.00			1,556.51
Supplies	1,542.38	0.00			1,542.38
Equipment	0.00	0.00			0.00
Communications	328.26	0.00			328.26
Shipping/Freight	0.00	0.00			0.00
Publications	14.13	0.00			14.13
Other direct costs	0.00	0.00			0.00
Indirect costs	1,346.27	0.00	538.36		1,884.63
TOTAL	7,151.57	0.00	1,790.36	0.00	8,941.93

[a]Host and external contributions have not been determined.

Global Thrust 3. Outreach

Soil Management CRSP
Annual Work Plan and Budget

Fiscal Year: 1993-94

Project Number: COM-1

Title: Communications

Global Thrust: Outreach

Constraints Addressed:
1. The size and diversity of the population that lacks information on appropriate soil-management technologies;
2. The lack of scientific expertise that often characterizes this population;
3. The gap between new information and applied knowledge;
4. The lack of site-specific management recommendations that assess biophysical, cultural, and economic variables;
5. Inadequate communication and collaboration among various research organizations, policy-makers, and public officials.

Collaborators and Institutions:
The project leader will work with each technical coordinator (and with various project leaders) to obtain project updates. A working relationship will also be established with directors and peers in the other CRSPs, the communications section at NifTAL, and the editors at *Front Lines* and *Star*.

Objectives:
Outreach Thrust is intended to translate research results into applied information. In addition to organizing and publishing material useful to technology-adoption personnel, COM-1 also seeks to communicate research goals, gaps, and results to various national and international organizations, thus encouraging the integration of institutional strengths into efforts to achieve sustainable soil, water, and nutrient management.

In view of these ends, COM-1 targets two broad goals:

1. To organize and publish information that will have the widest possible impact on ameliorating globally significant soil-management problems;
2. To convey TropSoils' purpose, plans, and achievements to an audience of prospective collaborators, as well as to public officials, policy-makers and private entrepreneurs.

To meet these goals, Com-1 will:

* Produce publications on those subjects that the technical committee determines will be most useful to field staff and other technology-adoption personnel;

* Provide technical bulletins on those subjects that the technical committee feels will be most useful to scientists and educators working to establish agricultural systems that are culturally appropriate, economically productive, and environmentally sustainable.

* Collect information from project leaders about the program's plans and achievements; organize, arrange, and distribute that information;

* Assist the management entity in providing required documentation and communications materials.

Progress Report:
* In early 1993, a partial draft of *Groundworks 2, Managing Soil Phosphorus* was reviewed by a number of scientists working on the PDSS system. As of September 1993, *Groundworks 2* is on hold, pending refinements in the PDSS system.

* 1000 copies of the technical bulletin *Legume Green Manures: Dry-Season Survival and the Effect on Succeeding Maize Crops* were published in January of 1993.

* As of September 1993, *Land Clearing and Reclamation of Ultisols and Oxisols* was entering the final stages of editing and layout.

* Availability of all new CRSP publications were announced in the bimonthly *Newswire.* Com-1 responded to several hundred requests for these publications.

* In January of 1993, two Impact Sheets were prepared for the Management Entity Director's visit to Washington: *Soil Restoration and Sustainability in the Sahel* and *Sustainable Savannas: A New Role for Legume Green Manures.*

* In February 1993, Com-1 published an article in USAID's *Front Lines*, "Hillside Erosion: A Threat to the Philippines."

* A bimonthly *Newswire* was initiated in 1992. Mailing lists are updated with each issue. Based on recommendations of the Management Entity Director, Com-1 established an initial list of 420 readers. That number has now grown to over 1,000 readers.

* In April of 1993, Com-1 edited, redesigned, and printed the CRSP Council Publication *Global Research for Sustainable Development.*

* In May of 1993, Com-1 published an article in USAID's *Front Lines,* "Niger Field Day Tests Soil, Crop Treatments."

* At the request of USAID Program Coordinator, Com-1 began sending weekly "silver bullets" to Washington; these consist of brief summaries of CRSP activities and impacts. A compendium of these summaries are on file in the ME Director's office.

* As of September 1993, the text for a 12-year summary of program achievements was nearing completion. The tentative title for the document was *Looking to the Earth: A Foundation for Sustainable Development.*

* The Management Entity Director (Dr. Roger Hanson) and the Interim Planning Coordinator (Dr. Charles McCants) have been provided with slides and overheads as requested for a variety of public appearances.

* Com-1 worked extensively with the ME and NCSU's McKimmon Center in preparation for the January 1993 Global Planning Workshop. Activities ranged from preparing the preliminary workshop documents, to obtaining computer setups for software displays, to designing caps for workshop participants.

* A 117-page *Workshop Record* was compiled, edited, designed, printed, and circulated in March of 1993.

* Com-1 helped to write, edit, and design numerous preliminary drafts of the *1994-1999 Proposal for Extension,* due for submission in December of 1993.

Work Planned for Next Year:
1. *TropSoils Newswire*, a bimonthly update of program news, plans, and accomplishments for an audience of about 1000 readers;
2. Several technical bulletins, as selected by the technical committee and drafted by PIs;
3. *Groundworks 2, Managing Soil Phosphorus*--with cooperation from PDSS developers;
4. A 12-year report on the program's accomplishments;
5. News articles and photographs for publications like *Front Lines* and *Star*;
6. Publications and editorial support as requested by the management entity in preparing the 1994 Extension Proposal;
7. A complete bibliography of Soil Management CRSP publications.
8. A survey of Soil Management CRSP graduates.
9. New and updated mailing lists.

Project Leader and Institution: Tim McBride, NCSU

Research Sites: Not applicable.

Budget: COM-1

Object	Total Funding Source				
	CRSP	External	Matching	Host	Total
			x 100		
Salaries	380	–	–	–	380
Benefits	87	–	–	–	87
Allowances	–	–	–	–	–
Travel, U.S.	10	–	–	–	10
Travel, Int.	5	–	–	–	5
Supplies	10	–	–	–	10
Equipment	30	–	–	–	30
Publications	310	–	–	–	310
Mailing Costs	100	–	–	–	100
Other Direct Costs	160	–	–	–	160
Indirect Costs	499	–	–	–	499
Total	1591				1591

Human Resource Commitments:

Institutional	Full-Time Equivalents (FTE)			
	Specialist	Project Support	Other	Total
U.S.	1.0	–	–	1.0
Host	–	–	–	–
Other	–	–	–	–
Total	1.0	–	–	1.0

Timothy R. McBride 6/28/93

Project Leader (Date)

Roger G. Hanson 7/21/93

Director, CRSP ME (Date)

SOIL MANAGEMENT CRSP
ANNUAL ACTIVITY WORK PLAN AND BUDGET REQUEST

Fiscal Year: 1993-1994

Project Number: TSMM/Economics

Title: Economics of Soil, Water, Vegetation and Livestock Management

Global Thrust: Natural Resource Management

Constraints Addressed: Landscape restrictions
Climatic variability
Production-demand pressure
Inadequate resource information

Principal Investigators and Institutions:

W. Butcher, WSU	Department of Agricultural Economics
D. Taylor, VPI	Department of Agricultural Economics
F. Boadu, TAMU	Department of Agricultural Economics

Collaborators and Institutions:

A. US Universities
D. Deybe, WSU - Department of Agricultural Economics, Field Research Leader
C. Stockle, WSU - Department of Biosystems Engineering, Responsible for biophysical modelling
I. Silva-Barbeau, VPI - Department of Rural Sociology, Leader, WID component
G. Carlson, NCSU - Department of Agricultural Economics, Principal Investigator, Yurimagues Data
J. Smyth, NCSU - Department of Soil Science, Coordinator of Yurimagues Study
P. Baveye, Cornell - Department of Soils, Crops, Atmos. Sc.
S. Riha, Cornell - Department of Soils, Crops, Atmos. Sc.
A. Van Wambeke, Cornell - Department of Soils, Crops, Atmos. Sc.
Coordinators Soils Research Morocco and Burkina Faso

B. Overseas Entities
Institut National de la Recherche Agricole
Centre d'Aridoculture, Settat, Morocco
M. El Mourrid - Director of Center, Soil Scientist
M. Bendaoud - Agricultural Economist, PI
M. Boughlala - Soil Scientist
M. Laamari - Agricultural Economist
M. Moussaoui - Agricultural Economist
In-country principal investigator and collaborators at Settat.

Institut Agronomique et Veterinaire Hassan II, Rabat, Morocco
Department de Sciences Sociales and Department de Sciences du Sol
R. Doukkali, Head, Agricultural Economics, PI
Y. Bathaoui, Agricultural Economist
M. Taya, Soil Scientist
In-country principal investigator and collaborators at Hassan II.

Institut d'Etudes et de Recherche Agricole, Burkina Faso
S. Ouedraogo - Director, RSP, Ag Economist, PI
F. Lompo - Director, ESFIMA, Soil Scientist
In-country principal investigator and collaborator at INERA.

Institut d'Economie Rurale, Mali
A. Maiga - Agricultural Economist, PI

ICRISAT/Sahelian Center
S. Deborah - Agricultural Economist, Mali Station
R. Shetty - Head, Farm Resources Unit, Niamey
In-country principal investigator and collaborators in Mali.

PARC Forestier HANN, Senegal
A. Niang - Director, Senegal Reforestation Project
Coordination and field logistics support WID study.

Centre de Cooperation Internationale en Recherche Agronomique Pour le Development, France
F. Girard, URPA - Agricultural Economist
Collaborator on Macro Studies in West Africa

Objectives:

In the vast majority of cases in developing countries crop yields are extremely low and generally insufficient to provide nutritional requirements of rural farm families. Animal productivity is also low. Low crop and livestock productivity in turn means that cash income is low and farm families are unable to purchase the food, clothing, medical care, and other necessary goods and services. Standards of living are declining. Moreover, high population growth and reduced productivity has set in motion a trend of increasingly intensive cultivation leading to serious negative consequences for the environment. The result is growing uncertainty regarding the long run sustainability of these agricultural systems.

The overall goal of the SM-CRSP/TSMM Economics Program is to identify farm technologies and resource management practices that will improve income, food production and consumption, and preserve the long-term productive capacity of natural resources. Efforts this year will address the need to:

1. Develop multi-disciplinary analytical methodologies effectively integrating soils, agronomic, agroclimatic, and economic data for accurate assessment of soil and water management practices and related land use strategies.

2. Assemble baseline and response data suitable for use in the methods and procedures of Item 1.

3. Identify sustainable agricultural production systems through socioeconomic analyses of soil, water, vegetation, and livestock management options.

Progress Report:

Washington State University
The planned effort to study socio-economic factors associated with resource use and management in the Hamdallaye Watershed in Niger was abandoned following termination of the SM-CRSP/TAMU project and program. The WSU program was redirected. Emphasis was given to Morocco, following up on previous contacts, and the work in Burkina Faso as planned.

Burkina Faso
Economic models were developed for typical farms and for a village level farm economy in the cotton area of SW Burkina Faso. Emphasis was placed on interactions between common lands and private lands. A joint paper was prepared reporting results of using the models.

A plan of work has been developed for economic/agronomic studies emphasizing management and conservation of soil and other natural resources. Questionnaires have been adapted for use in farm and household surveys in Burkina Faso.

Other
A dynamic economic analysis of length of fallow alternatives in western Sudan and a PhD thesis based on the study are nearing completion.

WSU researchers participated in planning and design of the new SANREM CRSP and in developing economic indicators of sustainability.

A hierarchial modeling approach has been refined and adapted to an economic study of a newly privatized state farm in Mongolia. Collection of data has started. Emphasis is placed on increasing productivity without depleting the natural resources -- especially the common grazing lands.

Agreements and plans for collaborative research with Moroccan economists and soils/agronomy scientists have been drawn up and work was begun.

Virginia Tech University
As planned, VPI collaborators focussed their efforts on two activities, viz., analysis of data from Mali and Senegal. In addition, discussions began regarding new collaborative research in Mali. The VPI planned activity to support the WSU Niger program of work on farming systems analysis and WID was also abandoned.

Mali
Statistical analysis of Dr. Ram Shetty's agronomic data (ICRISAT trials) was completed and a final report is in preparation. Updating of the Mali whole-farm economic model was postponed pending identification of new study sites and farming systems as part of a new collaborative study.

Senegal
The wood marketing study has been completed resulting in an MS thesis. Visits to Senegal to discuss WID research were completed and agreement was reached with USAID/Senegal to implement a study in collaboration with AID's Senegal Reforestation Project.

North Carolina State University
The planned feasibility analysis of private sector support to farmers in the Santa Cruz area of Bolivia for technical, financial, and marketing assistance was finished and an MS thesis is in final stages of completion. The planned ex-post analysis of the NCSU Yurimagues, Peru data did not materialize due to unavailability of the NCSU economist.

University of Hawaii
Budget cuts prevented continuation of the planned support to the PDSS program at Hawaii.

University of Wisconsin
Informal collaboration with UoW researchers on the role of credit and land tenure issues in resource conservation continues. Field data collection is underway at the present time in upland regions of the Philippines. Budget limitations prevented financial support to this effort.

Work Planned for Next Year:
Through the USAID funded Technology for Soil Moisture Management project (TSMM) the Economic Research Service is the lead entity in the SM-CRSP socioeconomic program of work. This program is now known as the CRSP Soils Management/TSMM Economics Program. In order to achieve program objectives, ERS provides technical leadership, research input, administrative management and funding support to collaborating scientist in research and training institutions.

Work carried out at the various locations is planned and coordinated to achieve overall program objectives. Primary ERS collaborators during FY-1993 will be: Washington State University, Virginia Polytechnic Institute and State University, North Carolina State University, Texas A&M University and Cornell University.

The scope of work for each collaborating institution follows.

Virginia Tech University
At VPI, PhD candidate Debrah Wagner will complete the field work for her dissertation in the fall of FY 1994. She is examining the role of women in farm household decision-making and their income earning status relative to resource conservation and management strategies. The study site is Senegal. The research will be conducted in three Communaute Rurale: MBellacadio near Fatik, Thiare near Kaoluck, and Bamba near Tambacoonda. The study is in collaboration with USAID/Senegal and its Senegal Reforestation Project (SRP). The Mission is providing all logistical support for the field work. Analysis of the data will continue through FY 1994.

Specific activities in this WID study are:
1. Summarize the literature on gender issues pertaining to natural resource management.
2. Finalize a research plan for addressing critical aspects of this issue in the research sites.
3. Collect the data.
4. Analyze the data.
5. Complete a draft PhD dissertation.

In addition, VPI Principal Investigator Dan Taylor and TAMU PI Fred Boadu will continue discussions now underway with Dr. Alpha Maiga, economist at IER, Mali, and with Dr. Siegfried Deborah, ICRISAT economist based in Mali, regarding a study to begin in the Fall. This will be a collaborative effort involving complementary work by ICRISAT, IER, VPI and TAMU. Specific details of this proposed activity have not been developed at this point in time; however, the following activities are planned:
1. Assess the availability of data for developing crop response data and stochastic dominance analyses for various management practices.
2. Update TSMM Mali whole-farm economic models, and if feasible, a moisture balance/crop response previously adapted for use in TSMM/EC farming systems analyses.
3. Assess the viability of employing physical simulation models to project crop yield under various management practices.

VPI collaboration with Dr. Ram Shetty, ICRISAT/Niamey, will continue. Work planned for this year will:
1. Complete the physical analysis of the agronomic data set developed in collaboration with Dr. Ram Shetty of ICRISAT Sahelian Center, which contains data spanning eight crops and intercrop systems over a three to four year time period.
2. Prepare enterprise budgets for these agronomic data sets and complete their economic analysis.

Texas A&M University

At TAMU, Dr. Fred Boadu has established excellent rapport with Dr. Siegfried Deborah, ICRISAT economist stationed in Mali, and agreements have been reached to work collaboratively. In that connection field work will be carried out this summer in Mali to:

1. Determine and quantify the welfare implications of household use of alternative water management technologies.
2. Estimate the households' willingness to pay for selected water management technologies.

Ms. Beth Scott, MS candidate at TAMU, will gather the necessary data from seven villages which are part of the ICRISAT farming systems survey of Dr. Deborah. This new data will be combined with Deborah's data sets and analyzed over the course of the year leading to an MS thesis in the fall of FY 1995.

In addition, as indicated above, Dr. Boadu will also collaborate with Dan Taylor, VPI, on development of a broad program of soils related socio-economic research and TA in Mali. Note: the TSMM/EC TAMU project had to be redesigned and redirected following the termination of the TropSoils program in Niger.

North Carolina State University

As a carry-over from last year, discussions continue with Dr. Gerald Carlson regarding an economic analysis of the NCSU Yurimagues, Peru data. Jot Smyth and John Day are searching for ways to do an ex-post evaluation of this data through joint support for a small study. Dr. Carlson has expressed some interest in such an effort and is studying the information. The nature of the study is yet to be determine, but could involve a graduate student in the economics department for part of fiscal year 1994.

Washington State University

Burkina Faso

Washington State University economists will work with INERA economists and agronomy/soils scientists in a study of soil management and conservation in newly settled, cotton-producing areas of southwestern Burkina Faso. Collaborative work will also be undertaken with INERA and SANREM in the more arid central-plateau area. It is expected that soil scientists at Cornell University will participate in this project. Objectives are to:

1. Identify typical farm-household characteristics, resource management practices, and socio-economic incentives and constraints.
2. Determine the relation between agriculture and the long-run condition of land and other natural resources.
3. Identify principal household and community level decision rules and constraints that affect resource use and management, and evaluate the efficiency and effectiveness of policy alternatives.
4. Develop in-country capability for socio-economic analysis of sustainable natural resource use and management.

Morocco Project (Collaborative with INRA and University of IAV Hassan II)
WSU economists and soil scientists will collaborate with INRA and IAV in an agronomic and socio-economic study of two agricultural watersheds in central Morocco. Soil scientists at Cornell University have expressed interest in Morocco and we expect them to participate in this project. Objectives are to:

1. Identify typical farm-household characteristics, resource management practices, and socio-economic incentives and constraints.
2. Determine the relation between agriculture and the long-run condition of land and other natural resources.
3. Identify principal household and community level decision rules and constraints that affect resource use and management, and evaluate the efficiency and effectiveness of policy alternatives.
4. Develop in-country capability for socio-economic analysis of sustainable natural resource use and management.

Research Sites: Washington, DC; Raleigh, NC; Pullman, WA; Blacksburg, VA; College Station, TX; Senegal; Morocco; Burkina Faso; Mali.

Budget:

	Total Funding Source, ($1000)				
OBJECT	CRSP	EXTERNAL	MATCHING	HOST	TOTAL
Salaries	247		103	20	370
Fringe Benefits	36		15		51
Allowances	0				0
Consulting	0				0
Travel, US	12				12
Travel, INT	68				68
Supplies	12		5		17
Equipment	15		6		21
Communications	4				4
Shipping/Freight	0				0
Publication	5				5
Other Direct Cost	0	10	38		48
Indirect Costs	0				0
Total	399	10	167	20	596

Special Budget Requirements:

Human Resource Commitments:

	Full Time Equivalents (FTE)				
	SCIENTISTS				
INSTITUTION	SENIOR	JUNIOR	TECHNICIAN	ADM. SUPPORT	TOTAL
US	2.8	5.5	2.7	2.2	13.2
Host	4.0	4.0	3.0	1.2	12.2
Other	-	-	-	-	-
Total	6.8	9.5	5.7	3.4	25.4

Narrative explanation of human resources:

This research program is implemented through USDA/ERS cooperative research agreements with Washington State University, Virginia Tech, and Texas A&M. Collaborative work is also carried under these agreements in Morocco, Burkina Faso, Mali, and Senegal. FTE Staff includes government personnel, U.S. university faculty, post-doctorate researchers, graduate students, hourly technical support personnel, administrative support personnel and collaborating equivalents overseas. Salaries and benefits plus associated research costs for these personnel are reimbursed to the Cooperative entities by USDA/ERS using AID grant funds. Formal involvement of scientists at NCSU and Cornell University is pending.

SOIL MANAGEMENT CRSP
ANNUAL ACTIVITY WORK PLAN AND BUDGET REQUEST

Fiscal Year: 1993-1994

Project Number: NCSU 5

Title: Technical Support for Research Networks in the Humid Tropics

Global Thrust: Outreach

Constraints Addressed: Many key components of soil management options can now be transferred to national institutions for validation and extrapolation across the humid tropics. National institution involvement is important for several reasons:

1. Available resources limit the extent to which TropSoils alone can systematically validate developed technology.
2. If developed technology is to be used, information must be disseminated and local soil management expertise must be acquired.
3. Feedback from its eventual users will enhance TropSoils' ability to develop agronomically and economically sound soil management practices through refinements or modifications of ongoing research.

Attempts to perform such technology transfer require a minimum level of on-site expertise in collaborating national institutions, and an organizational framework conducive to and supportive of systematic evaluations of results. Research networks are an effective means for both tapping local personnel and providing useful training to scientists in collaborating countries.

Principal Investigators and Institutions:

T.J. Smyth - NCSU

Collaborators and Institutions:

A. U.S. and International Institutions

S.W. Buol - NCSU, soil characterization and FCC system dissemination/improvement

F.R. Cox - NCSU, Phosphorus Decision Support System

R.S. Yost - Univ. Hawaii, Phosphorus Decision Support System

W.R. Raun - Oklahoma St. Univ., translation and editing of RISTROP workshop proceedings

K. Pond - Small Ruminant CRSP and silvopastoral system development for the Chapare, Bolivia

Elio Duron - NCSU graduate student conducting dissertation research on agronomic effectiveness of North Carolina phosphate rock in Central America soils derived from volcanic ash

Armando Ferrufino - NCSU future graduate student to conduct dissertation research on silvopastoral systems in Chapare, Bolivia

J. Bolaños - CIMMYT/Central American & Caribbean Strategic Agronomic Trials

J. Espinosa - INPOFOS/Potash & Phosphate Institute
E. Fernandes - NCSU, based in Manaus and providing technical backstopping to agroforestry trials in Calabacito, Panama and Porto Velho, Brazil
K. Cassel - NCSU, technical backstopping in Central America on tillage practices in Panama and steepland research in Central America

B. National Institutions
B. Narne, R. Sanchez & S. Jaramillo - IDIAP, Calabacito, Panama
E. Molina & A. Alvarado - UCR/CIA, La Selva, Costa Rica
O. Garcia - SRN, La Esperanza, Honduras
M. Locatelli - EMBRAPA/Porto Velho
F. Lastra - IBTA/Chapare

Objectives:

1. To strengthen capabilities of personnel at network collaborating national research institutions to conduct, interpret and report user-oriented research.
2. To systematically validate and extrapolate available soil management technologies to regions beyond the TropSoils research sites.

Progress Report: In-house English translation and typesetting of the proceedings for the RISTROP workshop held in Costa Rica in 1990 is 80% complete. Dr. W.R. Raun has been remains fully involved in the editorial process, despite his departure from CIMMYT to assurne domestic responsibilities with Oklahoma State University.

With the termination of supplementary grant support to RISTROP from AID/R&D efforts were re-directed towards identifying donors to support specific network activities and establishing linkages with network collaborators. Several Central American collaborators succeeded in obtaining funding for multi-institutional activities from the European Economic Community. This will allow them to pursue ideas conceptualized during the RISTROP workshop in 1990. Through direct grants to IDIAP, INPOFOS has assured continuation of K fertilization studies and initiation of a long-term experiment on fertilizer P rates and placement for Ultisols in Calabacito, Panama. Based on five years of field data the critical soil K level for corn has been established at 0.10 cmol kg^{-1} for both the Mehlich 1 and ammonium acetate extraction; despite residue maintenance residual effects from 210 kg K ha^{-1} only lasted four years, but annual applications of 42 kg K ha^{-1} have maintained near-maximum yields. The long-term P rates and placement trial was designed to provide yield and soil P dynamics data according to input requirements of the current PDSS prototype.

Through a grant from Texasgulf, Elio Duron has directed his dissertation research to field evaluations on the comparative effectiveness of North Carolina phosphate rock (NCPR) and triple superphosphate. These studies completed their first year in Ultisols at Costa Rica and Panama, and their second year in an Andisol in Honduras. Test crops were a rice-cowpea rotation in the Ultisols and highland corn in Honduras. Although yields were increased with applied P, preliminary analysis of yield data suggests no difference in yield response between P sources in either Honduras (with corn) or the unlimed Ultisol in Panama (with rice). For the Ultisol in Costa Rica, low but measurable

rice yields were only obtained in the with either NCPR or limed treatments, which suggested a low tolerance to high soil Al for the locally recommended variety.

From his Manaus base under a non-CRSP program, Dr. Erick Fernandes provided technical backstopping to network trials Brazil and Panama for selection of legume trees for multipurpose use. Erick's recommended adjustments in P treatments and measurements for an ongoing *Gliricidia sepium* provenance trial on the acid, P-deficient Ultisols in Panama will allow further screening of materials which were tolerant to high acidity in Yurimaguas under conditions of both high Al and low available P.

During travels through Central America, Keith Cassel provided technical advise IDIAP's participants in the CIMMYT network on tillage practices as related to runoff and erosion on mechanically cultivated lands in Azuero, Panama. Opportunities for initiating collaborative research towards quantifying erosion/runoff reductions by legume cover crop practices of farmers on the Atlantic Coast steepland areas of Honduras were evaluated during site visits with CIMMYT, CURLA and SRN scientists.

Reductions in annual funding from that requested to the CRSP eliminated the graduate stipend to initiate systematic screening of crop germplasm for tolerance to soil conditions of high Al and low available P. Nevertheless an initial greenhouse screening for Al tolerance was conducted with non-CRSP funds on purified rice lines collected by IDIAP from shifting cultivators in Ultisols of Panama. Relative to rice cultivars provided by several national and international centers, root growth under high solution Al concentration suggested that the Panama lines would be promising materials for low input management systems.

Work Planned for Next Year: The English version of the RISTROP proceedings will be completed and distributed by the first trimester of 1994. We will continue to provide technical backstopping assistance to network studies using the same format as in last year, i.e. pooling available resources among projects and maximizing activities covered during each travel event.

Field trials on the agronomic effectiveness of NCPR and TSP in Costa Rica, Honduras, and Panama will continue for an additional year. Collaborators at each site monitor daily activities and Elio Duron travels to all sites during critical periods of planting and/or harvesting twice a year. Soil and plant samples from all sites are returned to NCSU for analysis in a single laboratory. Measurements include: grain and stover yield and P uptake; mineralogical and chemical soil characterization; routine soil test analyses; and Modified Olsen, Bray 1, and Fe-paper-strip extractable soil P dynamics in the broadcast P treatments.

A second phase of Elio Duron's research will be laboratory and greenhouse experiments with surface (0-20 cm) samples from 10 soils collected in five Central America countries. These sites were chosen for sampling 1) based on a confirmed response to fertilizer P during two consecutive years of field trials in CIMMYT's Strategic Agronomic Trials Network, and 2) using criteria to ensure a diversity of soil conditions known to influence P availability (namely acidity, mineralogy, clay content, and P fixation capacity). This work will address information gaps identified during the PDSS workshop in 1992 which needed further research. Specifically these are 1) 'prediction of critical P

levels for soils that vary in mineralogy', and 2) 'prediction of buffer coefficients that include major factors associated with soil P sorption'.

Samples will be collected in Costa Rica, El Salvador, Guatemala, Honduras, and Panama in June-July 1993 during Elio's travel to monitor field trials. Soils will be treated with five rates of P fertilizer and available P by several soil test methods will be measured after incubation for periods ranging from 2 hours to 12 weeks. Yield response curves will also be developed in greenhouse trials at NCSU. Differences in critical P levels and fertilizer P requirements among soils will be related to variations in mineralogy, chemical properties, and buffer coefficients.

During a visit to Chapare, Bolivia in December 1992, T. Grove and J. Smyth reviewed ongoing studies at IBTA's Chipiriri Experiment Station with hairless sheep. Small ruminant specialists had achieved impressive production levels and cost/benefit indices by extrapolating "best animal management practices" developed in other regions. IBTA/Chapare expressed a strong interest in a collaborative investigation with the Soil Management and Small Ruminant CRSPs to develop management practices for hairless sheep-grass-tree systems in this perudic environment. Despite the promising initial results, scientists at Chipiriri are concerned about the long-term stability of silvopastoral systems and the extent to which animal/tree competition and overgrazing can be controlled by animal management. Armando Ferrufino would conduct his dissertation research on this topic under co-direction of Soil Management and Small Ruminant CRSP investigators at NCSU. Armando is scheduled to begin his Ph.D. program in August 1993.

Research Sites:

Calabacito, Panama; Rio Frio, Costa Rica; La Esperanza, Honduras; Porto Velho, Brazil; and Chipiriri and La Jota, Bolivia.

Budget:

Total Funding Source, US $1000's

OBJECT	CRSP	EXTERNAL	MATCHING	HOST	TOTAL
Salaries	18.8	18.0	10.6	55.0	102.4
Fringe Benefits	1.8	0.0	2.6	0.0	4.4
Tuition Remission	11.0	0.0	0.0	0.0	11.0
Allowances	1.0	1.5	0.0	2.0	4.5
Consulting	0.0	0.0	0.0	0.0	0.0
Travel, US	1.0	0.0	0.0	0.0	1.0
Travel, Int.	6.0	3.0	0.0	0.0	9.0
Supplies	4.4	0.0	0.0	5.0	9.4
Equipment	0.0	0.0	0.0	0.0	0.0
Communication	3.6	0.0	0.0	1.0	4.6
Shipping/Freight	2.4	0.0	0.0	0.0	2.4
Publication	0.0	0.0	0.0	0.0	0.0
Other Direct Costs	3.0	0.0	0.0	3.0	6.0
Indirect Costs	13.8	0.0	3.5	0.0	17.3
Total	66.7	22.5	16.7	66.0	171.9

Special Budget Requirements: Development of cooperative activities with the Small Ruminant CRSP in Chapare, Bolivia are conditioned to funds for a graduate stipend and a suitable applicant with interests in dissertation research on soil-plant-animal interactions. A suitable candidate has been identified, but graduate admission is conditioned to availability of funds.

Human Resource Commitments:

Full Time Equivalents (FTE)

	SCIENTISTS					
INSTITUTION	SENIOR	JUNIOR	TECHNICIAN	ADM. SUPPORT	OTHER	TOTAL
US	0.22	2.00	0.16	0.18	0.0	2.56
Host	2.00	5.00	3.00	2.00	6.00	18.00
Other	0.0	0.0	0.0	0.0	0.0	0.0
Total	2.22	7.00	3.16	2.18	6.00	20.56

Narrative explanation of human resources: Elio Duron maintains frequent contact with collaborators on P and K research in Central America, during his travels through the region. NCSU faculty provide backup support as specific needs are identified. J. Bolaños will coordinate with CIMMYT's network collaborators in El Salvador and Guatemala local assistance to Elio for soil sample collection. Erick Fernandes will continue to assist IDIAP scientists in agroforestry research through FAX and mail.

Date Initiated: September, 1987

Expected Completion: September, 1997

Signatures:

6-11-93

Principal Investigator Date

6-11-93

Program Coordinator Date

Principal Collaborator Date

Institutional Administrator Date

Instituto de Investigación Agropecuaria de Panamá
Idiap

APARTADO 6-4391 EL DORADO PANAMA 6A PANAMA TELEX 3677 PG FAX 649270

Divisa,19 de abril 1993

T. JOT SMYTH
Soil Science Department
North Carolina State University
Box 7619
Raleigh, N.C. 27695-7619
U. S. A.

Hemos revisado y estudiado el plan de trabajo, presentado por ustedes y TropSoil, a ejecutarse en la Estación Experimental de Calabacito.

Estamos de acuerdo con el mismo pretendemos sea ejecutado colaborativamente con TropSoil, North Carolina State University e IDIAP.

Atentamente,

BENJAMIN NAME TUÑON
Apartado 58
Santiago, Veraguas
Panamá

Teléfonos: Panamá 623711 • Divisa 971279 971168 • David 750293 753186 Los Santos 96-2763 • Rio Hato 93-3253

San José, 27 de abril de 1993

Elio Durón
North Carolina State University
TropSoils Research Program
FAX 919-515-7422

Estimado Elio:

Por este medio te envio adjunto la información de la cosecha del arroz, disculpándome por el atraso debido a que he estado un poco ocupado en las últimas semanas. Los datos se encuentran en gramos, el grano se secó a 14% de humedad. La parcela útil cosechada fue de 4.5 m^2.

El clima ha estado muy seco en las últimas semanas, pero yo espero sembrar en los próximos días, siempre que haya algo de humedad en el suelo.

Te agradezco tus gestiones con el electrodo, pero ya conseguimos uno.

Para tu próximo viaje a Costa Rica, me gustaría saber si es posible que traigas dos barrenos tipo holandés, desarmables, de 1.2 m de altura, los cuales son más funcionales para tomar las muestras de suelo.

El muestreo de suelos pienso hacerlo este viernes.

Hasta pronto.

Eloy Molina
FAX 506-341627

BEST AVAILABLE DOCUMENT

SECRETARIA DE RECURSOS NATURALES

NOTA # 114-93-DIA
26 de abril de 1993

Doctor
JOT SMYTH
Soil Science Department
Trop Soils Research Programa
Raleigh, N.C.

Estimado Doctor Smyth:

Como es de su conocimiento la Secretaría de Recursos Naturales, a través del Departamento de Investigación Agrícola en coordinación con el Programa de Investigación de Suelos Tropicales de la Universidad Estatal de Carolina del Norte, ha estado realizando estudios de investigación sobre fertilidad de suelos durante un período de 3 años específicamente haciendo evaluaciones con P_2O_5 teniendo como fuente principal Superfosfato triple (0-46-0) y Roca Fosforica.
En vista de que los resultados obtenidos hasta la fecha son muy satisfactorios la Secretaría de Recursos Naturales tiene particular interés en dar continuidad durante el periodo 93-94 a estos trabajos siempre y cuando se tengan las facilidades que su Programa ha venido suministrando.

En espera de continuar desarrollando actividades conjuntas con su institución me suscribo de usted.

Atentamente,

ING. ORLY GARCIA FERNANDEZ
Jefe Nacional de Investigación Agrícola

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SOIL MANAGEMENT CRSP
ANNUAL ACTIVITY WORK PLAN AND BUDGET REQUEST

Fiscal Year: 1993-1994

Project Number: SMSS

Title: Soil Management Support Services (SMSS)

FY 93 Overview:
SMSS became operational in its new mode, as a partner in the Soil Management CRSP, in FY 92. Mush of the effort, since then was spent in planning and developing activities or the coming years. The task is much easier today due to the solid foundation built up during the last decade and the global network of scientist and institutions that SMSS has. The network has enabled SMSS to keep abreast of needs and aspirations of the collaborating countries and thus the planned activities are demand driven and timely. The highlights of FY 92 were the training forums in India, Thailand, and the Philippines by which about 200 persons were trained in "Soil Taxonomy and sustainable land management". The workshop in India on "Stressed agroecosystems" has provided the basis for future work in this area and will be followed up with a workshop on "Agro-domains" in Thailand in 1994. The publication of the sixth edition of "Keys to Soil Taxonomy" marks the completion of the activities of most of the international committees. The Report of ICOMID is now accepted by SCS and the 1994 edition will include their recommendations.

Major program focus: Providing support services and assisting research and development in the area of natural resource assessment and development is the focus of the program. This stems from the fact that the natural resource base, specifically the soil resource base, is deteriorating, jeopardizing the sustainability of agriculture. The focus also stems from the large discrepancy between farmer's performance and research results which has called for a new emphasis to adjust technology to specific environments, so that technology translates to commercial reality. The focus is also due to the fact that SMSS is one of the few entities that works globally to enhance transfer of resource assessment and monitoring technology. The focus attains greater significance in the context of Agenda 21 of the UN Conference on Environment and Development, which has called for among other things:

- Conserving and managing resources;
- Combating deforestation, desertification, and drought;
- Promoting sustainable rural development, and
- Conserving biological diversity.

1994 ACTIVITY AREAS

- **Assist in the strengthening of LDC institutions and human resources to address the challenges of sustainable agricultural development.**

    1. Assist LDCs in developing soil survey programs and/or components of such programs including the utilization of soil survey information.

    2. Develop training programs in LDCs to meet their needs in the areas of soil survey, soil classification and soil management.

    3. Provide mechanisms for exchange of information through technical workshops, soil correlation meetings and participation in technical meetings organized by other organizations.

- **Collaborate with NCSS and NSSC in the development of technologies in priority areas to address global and regional constraints to agricultural development and discriminatory use of soils.**

    1. Act as the link between the SCS National Soil Survey Center and national and international soil survey organizations world wide.

    2. Develop and maintain a data base on world soils including GIS, to backstop national and international efforts in systems modelling and other uses of soil information.

    3. Maintain relationships with foreign donor agencies and the International Agricultural Research Centers and collaborate in mutually beneficial activities.

- **Use the resources of SCS, USDA and NCSS, to provide the scientific expertise to other Federal Government Agencies and international donors to carry out their respective mandates.**

    1. Coordinate SMSS activities with activities of the National Soil Survey Center, Federal agencies, and International agencies and institutions to ensure that information is integrated and shared.

    2. Provide information on soils of foreign countries to U.S. business, technical agencies, universities, publishers and where possible, arrange contacts in foreign countries to foster relationships.

    3. Actively support the EEO program and communicate this support to customers; assure equality in all activities; civil rights responsibilities include the obligation to cooperate with and provide planning support

services to individuals, groups, and publics without regard to race, religion, sex, or national origin.

- Assist in the development of networks of scientists and institutions to foster the development and application of innovative technologies in soil research and management.

  1. Provide support services to the Agency for International Development (AID), AID country Missions, and other international and regional institutions in the areas of problem identification, technical assistance in soil surveys and soil classification, training in these areas, and technology transfer.

  2. Assist in the development and distribution of technical monographs, newsletters and other documents including computer software to US and LDC institutions and scientists.

  3. Contribute to the utilization of soil information for sustainable land management and global climate change assessments.

SMSS PROGRAM OUTLINE

FY 1994

Activity	Coordinator	Country/Region	Institutions	Status[1]
1. Sustainable Land Management				
- Sust. Land Management	H. Eswaran M. Mausbach	Global	Multi	O
- Biophysical Constraints SLM	E. V. Den Berg	Indian Sub-cont.	ICRISAT	O
- Cimanuk Watershed	P. Reich	Indonesia	SRI	O
- Indicators SLM	H. Eswaran	Global	FAO/IBSRAM	O
2. Modeling & Documentation				
- GIS	P. Reich	Burundi	ISABU	O
- GIS	R. Almarez	Africa	Africa	O
		Czechoslovakia		O
		Rumania		O
		Albania	UA	O
- GIS	D. Yost	Egypt	NRC	O
		Sudan	SSS	O
		Somalia		O
		Ethiopia	DOA	O
		Kenya	SSK	O
		Mexico	UM	O
- GIS	H. Eswaran	Thailand	DLD	O
		Malaysia	DOA	O
- Soil moisture	E. Den Berg	Global		O
- Soil temperature	E. Den Berg	Global		O
- SMR/STR	B. Smallwood	US	SCS	O
- SMR/STR	B. Smallwood	N. America	Canada/Mexico	O
- Soil maps	D. Yost	Global		O
- Soil DBMS	E. Den Berg/ H. Eswaran	Global	F/FRED	O
- Benchmark soils	H. Eswaran	Bulgaria	ARI	O
- Soil degradation	R. Almarez	Africa		O
- Soil Map	H. Eswaran	Global	USGS/EPA	O
3. Databases				
- Soil Carbon	Reich/Eswaran	Global	All	O
- Soil Data base	Reich/Eswaran	Global	All	O
- Climate DB	Den Berg/ Eswaran/ Smallwood	Global	All	O
- AWHC	Reich/Eswaran	Global	All	O
- Soils DB	J. Kimble	Global	All	O

Activity	Coordinator	Country/Region	Institutions	Status[1]
4. Outreach				
- Soils info for schools	Reich/Eswaran	US	NEA	O
5. Technical Assistance				
- Supply of documentation	Almarez	Global	Missions/LDCs	O
- Project development		Sahel	IBSRAM/IFDC	O
- GIS support		Sri Lanka	USAID/SL	O
- Sust. Agr.	Eswaran	India	USAID/Delhi	O
- Site evaluation		Guinea	USAID/Conakry	O
- Data Base		Bolivia	USAID	O
6. Human Resource Development				
- ST Training	H. Eswaran J. Kimble R. Almarez	Zimbabwe	ZA	O
- ST Training	H. Eswaran F. Beinroth	Indonesia	SWMI	O
- ST Training	H. Eswaran J. Kimble	Thailand	DLD	O
- SLM Workshop	H. Eswaran	Global	IBSRAM	O
7. Publications				
- Soil Taxonomy	J. Witty H. Eswaran	Global		O
8. Networking				
- Africa Vertisol Network	H. Eswaran	Africa	IBSRAM	O
- Soil survey	H Eswaran	Global		O
9. Global Climate Change				
- Carbon sequestrat.	H. Eswaran P. Reich	Global		O
- Length Growing Season	H. Eswaran E. Den Berg	Indian Sub-cont.		C
- Length Growing Season	H. Eswaran E. Den Berg	Africa		O
- Length Growing Season	H. Eswaran E. Den Berg	U.S.		O
- Marginal Productivity	B. Smallwood H. Eswaran	Global	ERS	O
- Available Water DB	P. Reich	Global	IGBP	O
10. Private Enterprise Develop.				

Activity	Coordinator	Country/Region	Institutions	Status[1]
11. Resource Characterization				
- Resource Characterization	S. Holzhey C. Gordon	Mongolia	APRI	O
- Resource Characterization	??	Ivory Coast	WARDA	P
- Resource Characterization	??	Ethiopia	REDSO/EA	P
- Resource Characterization	??	Albania	IFDC	P
- Resource Characterization	??	Philippines	SANREM	P
12. Others				
- Taiwan Project Forest Soils	H. Eswaran	Taiwan	COA	P

[1] C = Completed; O = Ongoing; P = Planned

Services provided by SMSS

1. Technical assistance on assessment and monitoring of soil resources;
2. Training on soil resource assessment and monitoring, including utilization of computer data bases and Geographic Information Systems (GIS);
3. Characterization of soils at benchmark sites or on experimental stations, or in support of research activities;
4. Evaluation of potential sites such as water-sheds or catchments for siting research trials;
5. Compilation and evaluation of bio-physical resource base of selected areas for targeting or implementing sustainable agriculture activities.

Institutional linkages

1. International Soil Reference and Information Center, Wageningen, Netherlands
2. FAO, Rome, Italy
3. National Bureau of Soil Survey and Land Use Planning, Nagpur, India
4. International Crops Research Institute for the Semi-Arid Tropics, Hyderabad, India
5. Agriculture Canada, Ottawa, Canada
6. International Board for Soil Research and Development (IBSRAM), Thailand
7. Pakistan Agricultural Research Council (PARC)
8. National Chung Hsing University, Taichung, Taiwan
9. Council of Agriculture, Taiwan
10. Department of Land Development, Bangkok, Thailand
11. University Pertanian, Serdang, Malaysia

12. National Taiwan University, Taipeh, Taiwan
13. International Institute of Tropical Agriculture, Nigeria
14. University of Gent, Belgium
15. Bureau of Soils, Philippines
16. Soil Survey of Pakistan, Pakistan
17. Bangladesh Soil Research Institute
18. Soil Research Institute, Nanjing, PRC
19. CATIE, Costa Rica
20. CIAT, Columbia
21. Soil Survey of Zambia, Zambia
22. Department of Agriculture, Zimbabwe, Zimbabwe
23. Soil Research Institute, Ghana
24. INRA, Morocco
25. National Research Center, Egypt
26. ORSTOM, France

Annual Activities Budget:

Fiscal year '91[2] $143,930
Fiscal year '92 $639,458
Fiscal year '93 $623,000
Fiscal year '94 $562,110
Total $1,968,498

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[2] Information from Management Entity; recalculated to our fiscal year

Budget Fiscal Year 1994:

OBJECT	CRSP	TOTAL FUNDING SOURCE EXTERNAL	MATCHING	HOST	TOTAL
Salaries	180		120	100	400
Audio-visual	40				40
Travel, US	15		25		40
Travel, INT	80	40		50	170
Supplies	10		50		60
Equipment	10		50		60
Soil Analysis	85	50			135
Shipping/Freight	30	25			55
Publication	30			25	55
Training/Workshops	180	50		50	280
Indirect Costs	160				160
Total	820	165	245	225	1,455

SOIL MANAGEMENT CRSP
ANNUAL ACTIVITY WORK PLAN AND BUDGET REQUEST

Fiscal Year: 1993-1994

Project Number: TSMM-ARS

Title: Technology for Soil Moisture Management

Principal Investigator:

Dr. James F. Parr
National Program Leader for Dryland Agriculture & Soil Fertility
National Program Staff
USDA/ARS
Beltsville, MD 20705

Collaborators and Institutions:

C. Pairintra	Asia-Pacific Natural Agriculture Network (APNAN) Bangkok, Thailand
A. S. R. Juo	Texas A&M University and Texas Agricultural Experiment Station, College Station, TX
T. Higa	Department of Horticulture, University of the Ryukyus, Okinawa, Japan
V. Mezainis	USDA-OICD, Research and Scientific Exchanges Division (RSED), Washington, DC
J. H. Thomas	USDA-OICD, Far Eastern Regional Research Office (FERRO), New Delhi, India
I. G. Youngberg	Wallace Institute for Alternative Agriculture, Greenbelt, MD
A. Abdulaziz	Ministry of Agriculture & Fisheries, United Arab Emirates, Dubai, U.A.E.
I. Cakmak	Department of Soil Science, Cukurova University, Adana, Turkey
A. M. Elgala	Department of Soil Science, Ain Shams University, Cairo, Egypt
W. L. Hargrove	SANREM CRSP, Department of Agronomy, University of Georgia, Griffin, GA

I. Miyashita — Nature Farming Research and Development Foundation, Lompoc, CA

Research Sites: Thailand, Malaysia, India, Niger, Sri Lanka, Turkey, Egypt, United Arab Emirates

Global Thrust: Sustainable Agriculture Projection and Outreach

Constraints: Soil Chemical/Physical Limitations
Environmental Stress (Climate, Moisture, Heat)

Problem Statement:
Water is the major limiting factor to increased crop production under dryland/rainfed conditions. In addition to erratic and limited rainfall, many dryland areas of developing countries also have severe soil quality problems. These include low water-holding capacity; soil crusting and compaction; low water infiltration rates and excessive nutrient runoff losses; excessive soil erosion by wind and water; coarse-textured and shallow-depth soils; and low soil organic matter levels. Intensive cultivation of these marginal soils has led to an acceleration of degradative processes (e.g., erosion, salinization, and desertification) and an alarming decline in soil productivity.

The key to improving soil quality and increasing agricultural production and productivity in the arid and semiarid regions is through the proper and regular addition of organic amendments, primarily crop residues and animal manures. Yet in most cases such materials are not available because of competitive uses as forage, fuel, fiber and building materials. The agronomic and economic value of crop residues in the drylands of developing countries, in most cases, has not been determined. Consequently, there is an urgent need to explore possible "trade-offs" and strategies that would allow at least some of these residues to return to cropland as biofertilizers and soil conditioners.

Objectives:
The overall goals of TSMM are to increase the productivity and long-term sustainability of dryland/rainfed agricultural systems in developing countries, while maintaining or enhancing the natural resource base, specifically the soil and water resources, and improving output and income in crop and livestock production systems. More specifically the goals of TSMM are:

1. To assist in the assessment and improvement of soil, water and crop/livestock management systems under dryland or rainfed conditions.

2. To develop effective strategies and approaches for increasing dryland and rainfed agricultural productivity through research and technology transfer.

3. To strengthen the capability of developing country scientists and institutions for conducting research that would lead to more effective and efficient management practices for dryland and rainfed farming systems.

Justification:
For more than 50 years, U.S. scientists and particularly the ARS have conducted research throughout the U.S. Great Plains to deal with the extreme soil and agroclimatic problems and constraints to the development of sustainable dryland farming systems. Many of these same problems must now be dealt with by national scientists in the arid and semiarid regions where most of the world's basic food crops are grown. The most successful initiatives to develop effective soil, water and crop management systems in these regions has been through the establishment of scientist-to-scientist linkages. Agency-to-agency initiatives are seldom successful in developing meaningful and relevant research projects. Thus, there is an urgent need to identify capable and productive national scientists and to link them with other scientists at the international centers or in developed countries having similar agroecological conditions.

In establishing linkages with scientists in the semiarid regions, we need to gain a better understanding of dryland resources, the production potentials of those resources, and the scientific and socioeconomic systems within which they operate. In achieving the goals of the TSMM Project, we will utilize the following approaches:

1. Compile data bases and compendia of research data and information in countries of a particular region that are relevant to dryland or rainfed agriculture. The best and most logical approach in agricultural development initiatives is to determine what has already been done; where it was done and under what conditions; results obtained; conclusions drawn; and whether or not the technology was transferred to the farmer, and if so, whether it was adopted. Failure to compile such information usually results in an unusually slow startup time and ultimately a duplication of effort.

2. Conduct workshops to assess and discuss the data base findings and to establish research needs and priorities. A data base establishes what has been done, but at the same time it identifies knowledge and information gaps that must be dealt with. The workshop approach also helps to identify key scientists to be linked with other scientists on specific research projects.

3. Develop regional research networks in which scientists are linked by common research projects, objectives and methodology. Ideally, these projects should be conducted in both developing and developed countries with scientist-to-scientist linkages. This can greatly enhance mutual understanding and transfer of results and technologies to the farmer.

4. Conduct on-farm research using whole-farm analysis (agronomic and socioeconomic parameters) and model watersheds which should provide a more realistic and meaningful development of more sustainable farming systems in accordance with specific agroclimatic conditions and the individual farmer's interests, goals, and capabilities. This approach would also enhance the conservation of the natural resource base.

SPECIFIC ACTIVITIES (April 23, 1994 through April 22, 1994):

1. Assist in editing and publishing the Proceedings of the Second International Kyusei Nature Farming conference that was held October 7-13, 1991, at the University of Sao Paulo, Piracicaba, Brazil.

2. Assist in planning, organizing and conducting the Third International Kyusei Nature Farming Conference to be held October 5-8, 1993 in Santa Barbara, California.

3. Assist in editing and publishing the Proceedings of the Third International Kyusei Nature Farming Conference to the be held October 5-8, 1993 in Santa Barbara, California.

4. Assist the Ministry of Agriculture and Fisheries Staff, United Arab Emirates in compiling a database of research information on soil/water management resulting from agricultural development projects that were conducted over the past two decades.

5. Plan and organize a regional workshop on "Soil, Water and Crop Management Systems for Sandy/Saline Soils in Arid and Semiarid Environments", to be held in the United Arab Emirates in mid 1994.

6. Provide technical assistance to the Asia-Pacific Natural Agriculture Network (APNAN) which includes a review of SARE (LISA) research projects being conducted by 15 APNAN countries.

7. Serve as Team Leader of the U.S. Dryland Farming Team that will visit India in November 1993 to conduct an annual review of five major Indo-U.S. Cooperative Research Projects (26 sub-projects) on aspects of dryland/rainfed agriculture.

8. Serve as a Technical Consultant to NATO on a major research project that has just started (1993-1997) in Turkey under the auspices of the NATO Science and Stability Program. The project is being conducted by the Department of Soil Science, Cukurova University, Adana, and is entitled "Selection and Characterization of Cereal Genotypes with High Resistance to Zinc and Iron Deficiencies and Boron Toxicity for the GAP Region and Central Anatolia".

9. Plan, organize, and conduct the following workshops:

   a. U.S./Middle East Workshop on "Dryland Farming Systems and Technologies of a More Sustainable Agriculture". The workshop was requested by the State Dept./Bureau of Oceans, Environment and Science (OES) to enhance the Middle East Peace Initiatives and will be held at Washington State University, Pullman, Washington, during October 19-22, 1993. It will bring together Palestinian, Israeli and Arab scientists from the Middle East Region.

   b. Research Planning Workshop on "Production of Compost from Coconut Coir and Other Organic Wastes for Use as a Biofertilizer and Soil Conditioner" in Sri Lanka. An initial workshop to explore the feasibility of composting coconut coir dust was held in Kandy, Sri Lanka, in February 1994. This second research/utilization workshop requested by the USAID Mission in Colombo will be held in Kandy during late November 1993.

   c. A workshop on "Composting Coconut Coir and Poultry Manure" (as well as other organic wastes) will be conducted at the Central Arid Zone Research Institute, Jodhpur, India, in late November 1993. The workshop will be organized/conducted under the auspices of the Indian Council for Agricultural Research (ICAR), USAID/Delhi, and USAID/OICD/RSED/FERRO.

10. Assist the Henry A. Wallace Institute for Alternative Agriculture, Greenbelt, Maryland, to develop an international research and education outreach program that would enhance the productivity, stability, and long-term sustainability of small farmers under dryland/rainfed conditions.

Budget (April 23, 1993 through April 22, 1994):

TOTAL FUNDING SOURCE

OBJECT	CRSP	EXTERNAL*	MATCHING*	HOST*	TOTAL
Salaries	100,000				100,000
Fringe Benefits	40,000				40,000
Allowances	--				--
Consulting/Workshops	20,000				20,000
Travel, US	10,000				10,000
Travel, INT	25,000				25,000
Supplies	1,000				1,000
Equipment	25,000				25,000
Communications	1,000				1,000
Shipping/Freight	1,000				1,000
Publications	5,000				5,000
Other Direct Costs	--				--
Indirect Costs	20,000				20,000
Total	248,000				248,000

*Not yet determined.

Human Resource Commitments:

Full Time Equivalents (FTE)

INSTITUTION	SCIENTISTS SENIOR	SCIENTISTS JUNIOR	TECHNICIAN	ADM. SUPPORT	TOTAL
US	1.2			1.0	3.2
Host					
Other					
Total	1.2			1.0	3.2

Date Initiated:

Expected Completion:

SOIL MANAGEMENT CRSP
ANNUAL ACTIVITY WORK PLAN AND BUDGET REQUEST

Fiscal Year: 1993-1994

Project Number: UHTX-02

Title: Resource data base management for systems application

Global Thrust: Outreach/Sustainable Development

Constraints Addressed: Inadequate means of storing, organizing, and accessing information and data from past and present research effort. No standardized means of storing information and technical data sets in a data base management system are available to organize what we already know.

Principal Investigators and Institutions:

G. Uehara	University of Hawaii
G. Y. Tsuji	University of Hawaii

Collaborators and Institutions:

W. T. Bowen, IFDC
J. Fownes, University of Hawaii
R. Caldwell, University of Hawaii
H. Eswaran, SCS/USDA
M. Habte, University of Hawaii
D. Hellums, IFDC
N. Hue, University of Hawaii
D. Imamura, University of Hawaii
J. W. Jones, University of Florida
Z. C. Li, University of Hawaii
P. Singleton, NifTAL, University of Hawaii
P. K. Thornton, IFDC
R. S. Yost, University of Hawaii

Objectives:

1. Establish information and data base management system for use in conjunction with decision support systems and geographical information systems.

2. Acquire technical information and data from past and ongoing research and organize them in a standardized data base management system.

   - Enter available data sets of potential sites and existing sites from other programs into the DBMS and test retrieval and application for ADSS, PDSS and other DSS. Sep 95, Imamura, Tsuji.

- Use DSS software and data bases to address problem solving situations by providing alternative outcomes to different planned strategies. Mar 95, Uehara, Tsuji, Imamura.

Budget:

OBJECT	CRSP	EXTERNAL	MATCHING	HOST	TOTAL
Salaries	40,000	30,000	38,400		108,400
Fringe Benefits	8,000	9,600			17,600
Travel, US					
Travel, INT					
Supplies	1,000	3,000	600		4,600
Equipment					
Communications	1,000	1,200	750		2,950
Shipping/Freight					
Other					
Direct Cost	50,000	34,200	50,600		133,550
Indirect Costs	22,500	0	0		22,500
Total	72,500	34,200	50,600		156,050

Research Sites: Hawaii and collaboratively with IRRI and ICRAF in Indonesia, Philippines, and Thailand; and with IITA in selected West African countries.

Special Budget Requirements:

Describe special items or other support as needed by AID, host country or US institution to permit orderly execution of the work plan. Describe and indicate the budget for subprojects that are to be involved in the project. Budget requests for visiting scientists need descriptions and justifications. Country Mission approvals will eventually be needed.

None at this time.

Human Resource Commitments:

Full Time Equivalents (FTE)

INSTITUTION	SCIENTISTS SENIOR	SCIENTISTS JUNIOR	TECHNICIAN	ADM. SUPPORT	TOTAL
US	0.9	0.25	1.0	0.25	2.4
Host	0	0	0	0	0
Other	0	0	0	0	0
Total	0.9	0.25	1.0	0.25	2.4

Narrative explanation of human resources: One FTE will be required to handle the computer programming and data entry responsibilities. 0.25 FTE of a junior scientist to prepare computer documentation and 0.5 FTE of a senior scientist to develop and implement database management strategies and programs are planned. UH FTE is 0.4 for technical support of a senior scientist.

Date Initiated: 1991

Expected Completion: September 1994

SOIL MANAGEMENT CRSP
ANNUAL ACTIVITY WORK PLAN AND BUDGET REQUEST

Fiscal Year: 1993-1994

Project Number: TAMU-10

Title: Outreach Activities in the Semiarid Tropics

Global Thrust: Outreach

Constraints Addressed: Site specificity of management practives, lack of local expertise and communication channels, gap between new information and usable knowledge, number and diversity of potential users.

Principal Investigators and Institutions:
A.S.R. Juo - TAES, Texas A&M University
A. Manu - TAES, Texas A&M University

Collaborators and Institutions:
M. Oautarra - INRAN, Niger
O. Niangado - IER, Mali
Z. Kouyate - IER, Mali
R. Yost - University of Hawaii
A. Bationo - IFDC/ICRISAT, Niamey, Niger
T. McBride - TropSoils Management Entity

Objectives: The overall goal of this project is to establish links with national and international research organizations and synthesize and translate TropSoils-SAT research results into user-oriented products and disseminate these products to national users through networking, training and workshops. Specific objectives of this project are the following.

1. Identify national and international research organizations within the subregion and establish effective links to initiate collaborative research.
2. Synthesize and translate some of the more promising technologies into user-oriented products for easy dissemination.
3. Extend appropriate research findings to farmers through on-farm demonstration trials and organized field days.
4. Engage in the solicitation of external funding to finance collaborative research, workshops and training courses.

Progress Report: One of the major objectives of the outreach program is to promote and maintain close ties with national and International Research Organizations, Non-Governmental Organizations (NGO's) and Universities. Over the past year, collaborative research has been initiated with the following institutions.

- CIMMYT, Mexico
- National University, Heredia, Costa Rica
- INTSORMIL/Mali
- JARP/JADF, Jamaica
- LUPE Project, MNR, Honduras

Contributions to be made by these organizations to the SM-CRSP in support of collaborative research with TAMU are estimated at $100,315 for the upcoming year.

A. Juo participated in the project planning meeting on integrated soil/nutrient/water management for West Africa held in Lome, Togo, June 15-20, 1992. The meeting was jointly hosted by IFDC-Africa Center and IBSRAM. Invited participating institutions and countries included TropSoils CRSP (USA), ORSTOM and CIRAT (France), GTZ (Germany) and NARS from Ghana, Mali and Burkina Faso. The proposals are to be submitted to national and international donors for funding.

USAID Mission support for the second phase of IMAW (Integrated Management of Agricultural Watersheds) project is continuing at a funding level of $500,000 for a two year period. Two bulletins detailing an integrated approach towards the management of agricultural watersheds has been published (English and French versions) and made available to regional and international agencies, organizations and institutions.

A field day and workshop jointly organized by TropSoils/TAMU, INRAN and USAID/Niger was held on August 12, 1992 at Hamdallaye Watershed in Niger. The objective of this event was to familiarize area farmers and the scientific community of ongoing project activities and to solicit feedback from participants. The field day was attended by most of the farmers living and cultivating within the watershed as well as scientists and administrators from USAID, INRAN, ICRISAT, IFDC, ILCA, FAO, AFRICARE, UNDP, Peace Corps, the Ministry of Agriculture of Niger and Hamdallaye local government. A. Juo, L. Wilding of TropSoils/TAMU and R. Hanson, T. McBride of TropSoils Management Entity participated in the field day.

Finally, a joint effort of four TropSoils Universities involved an international workshop relating to TropSoils phosphorous decision support systems. This workshop was organized by the University of Hawaii and hosted by Texas A&M University on March 11-12, 1992.

Special and Miscellaneous Reports Published:

Manu, A., S.C. Geiger, A. Pfordresher Integrated Management of Agricultural Watersheds—Characterization of a Research Site near Hamdallaye, Niger, TropSoils Bulletin No. 91-03, 1991, 111 pp.

Taylor-Powell, E., Integrated Management of Agricultural Watersheds—Land Tenure and Indigenous Knowledge of Soil and Crop Management, TropSoils Bulletin No. 91-04, 1991.

Work Planned for Next Year:

Evaluation of IMAW Project and preparation of final report. Activities will also include the synthesis of some of the more promising technologies into user-oriented products in the French Language for dissemination to collaborators in the semiarid tropics.

Preparation of spatial variability report which reviews and synthesizes the results of nearly ten years of research conducted in Niger and Mali by TAMU/SM-CRSP researchers.

Actively engage in the solicitation of funding to carry out soils research in the semiarid tropics.

Maintain and establish linkages with national and international research organizations, non-Governmental organizations (NGOs) and universities.

Research Sites: Selected countries in the semiarid tropics of West Africa.

Budget (93-94): TAMU-10

Object	CRSP	External	Matching	Host	Total
Salaries	12,359.94	0.00	6,521.00		18,880.94
Fringe benefits	4,302.04	0.00	1,840.00		6,142.04
Allowances	0.00	0.00			0.00
Consulting	0.00	0.00			0.00
Travel, US	1,662.75	0.00			1,662.75
Travel, INT	6,325.51	0.00			6,325.51
Supplies	744.13	0.00			744.13
Equipment	0.00	0.00			0.00
Communications	962.75	0.00			962.75
Shipping/Freight	0.00	0.00			0.00
Publications	7,081.38	0.00			7,081.38
Other direct costs	0.00	0.00			0.00
Indirect costs	14,378.56	0.00	3,595.23		17,973.79
TOTAL	47,817.06	0.00	11,956.23	0.00	59,773.29

Human Resource Commitments:

	Full Time Equivalents (FTE)					
Institution	**Senior Scientist**	**Junior Scientist**	**Technician**	**Admin. Support**	**Other**	**Total**
US	0.29			0.26		0.55
Host						0.00
Other						0.00
Total	0.29	0.00	0.00	0.26	0.00	0.55

Date Initiated: November 1, 1990

Expected Completion: September 24, 1994

Signatures:

Project Leader	Date	Program Coordinator	Date

Merged Programs

SOIL MANAGEMENT CRSP
ANNUAL ACTIVITY WORK PLAN AND BUDGET REQUEST

Fiscal Year: 1993-1994

Project Number: NifTAL

Title: Nitrogen fixation for agriculture and agribusiness development

Executive Summary.

Program Change and Results Relevant to 1993-1994 Annual Plan. A year ago NifTAL increased focus on the linkage between research and the beneficiaries of BNF technology. This change included a shift in resources from Research to Development activities, primarily toward Program 5 - Technical Assistance to Commercial Inoculant Production. Resources allocated to research now approximate 50% of budget compared to more than 70% a year ago.

NifTAL significantly reduced molecular biology research in the last year, believing that results from the research program could not contribute to technologies and products immediately adaptable by private sector producers.

Other research areas have been curtailed or refocussed to increase the usefulness of results: 1) Work in basic *Rhizobium* ecology has been refocussed toward developing improved quality control methods for inoculant producers. Ecology research related to improving methodology to predict the response to inoculation in crop systems is still in progress with support from a grant with the Thai government. This work will have a direct bearing on NifTAL's ability to understand market potential for inoculant products. 2) Basic research on the basic physiology of BNF has been eliminated. We have developed an active coordination with crop modeling projects at IFDC and the Universities of Florida and Georgia for all field research involving crop development that can make a contribution to crop simulation model development. We intend to use other field data to improve the precision and usefulness of NifTAL's response decision support system.

USAID's increased emphasis on measurable economic impact requires NifTAL to expand efforts to implement already developed technologies at the expense of long range research. Efforts to package, test and apply existing technologies lagged behind research successes of the past. For example, small changes in existing fermentor design and manufacture protocols combined with cost analysis has led to the development of a Micro Production Unit (MPU) for inoculant. This design can meet the needs of clients manufacturing inoculant for small markets and will increase the number of countries where NifTAL can employ its technology.

We have increased our contact with inoculant producers both domestic and foreign. This contact has led to greater awareness of the real problems that NifTAL must solve to assist manufacturers of inoculant. We are now in a better position to target research and

development activities in areas where we have a comparative advantage and identify development needs that can have a real impact.

Highlights of Private Sector Initiative. Investment in private sector development has started to pay off in terms of results in the field and altered approach in our organization and operations. These activities and their relevance to the 1993-1994 Plan follow:

Created new disciplinary R&D structure - Product Development Matrix - for designing, developing, testing and distributing new NifTAL products (see Figure 1);

Designed a product testing network to evaluate feasibility and acceptability of NifTAL developed products;

Developed simple quality control protocols for inoculant to be tested in public and private labs in 1993-1994. These are to be disseminated within a network of inoculant producers for evaluation and then reworked to meet their needs;

Completed an economic impact assessment of NifTAL investment in BNF technology in Zambia. Another will be initiated for Thailand in 1993-1994. Results to be used in targeting other countries where the success can be replicated and assist AID in understanding the costs and benefits from investment in BNF technology;

Developing a database of inoculant producers that will form the basis for recipients of NifTAL developed technologies. This database will be distributed to missions and among the producers to foster communication and exchange of materials.

Program development with several AID mission projects and other donors from inoculant development facility development and marketing.

A new packaging system that increases shelf life of inoculant in adverse environments has received approval by the University for a patent application. Product is now ready for evaluation to select commercial companies that may be able to export inoculant in 1993-1994.

Other traditional activities with proven success and demand continue. These include strain acquisition, germplasm improvement and distribution; research inoculant services, plant systems and soil fertility research, graduate and technical training; collaboration with national and international agricultural research centers; bibliographic and information services.

NifTAL Mission. NifTAL's mission continues to be the same as stated in 1992 and is restated for reference to the activities that follow in the body of the 1993-1994 Annual Plan:

Ensure agricultural productivity and maintenance of natural resources are not limited by:

1) availability of plant symbiotic microorganisms;

2) management technology of symbiotic systems;
3) the fate of nutrient products derived from symbiosis.

Four primary constraints currently limit use of BNF technology and form the basis for activities within our Research and Development programs (see Log Frame Output Analysis - Table 1):

1) Insufficient use of quality inoculant;
2) Inadequate resident populations of rhizobia in soil;
3) Low legume yields, BNF, and conservation of BNF product;
4) Inadequate awareness, information, and capacity to exploit BNF technology.

Functional Organization of NifTAL.

Divisions and Programs. NifTAL remains organized around two Divisions: 1) **Development** and 2) **Research.** Priorities and problem identification, translation of technology into useable forms, and technology transfer are functions of the Development Division. Research generates fundamental technologies with potential use by NifTAL clients. These divisions integrate the Programs defined in the Subcontract Agreement to meet our goals (see Logical Framework Output Analysis). Programs 1, 2, and 3 are managed under the Research Division while most components of Programs 4, 5, Communications and Training fall under Development. Communications and Training provide service and derive input from all other programs. Division Heads act as coordinators and facilitate communication to ensure product and technology development meet client needs. Activities of NifTAL are executed within Programs. Each Program is managed by a Program Leader. Program leaders manage program budget and personnel, and are responsible for planning and reporting requirements and integrating activities with other programs and institutions.

NifTAL Programs. NifTAL continues to operate under the seven programs defined its Cooperative Agreement with USAID from 1986-1992. Many ongoing activities that were unique and critical to our success could not be fit directly into the CRSP functional programs. We note the CRSP *thrusts that are addressed in the following NifTAL Programs are in italics.*

* Technical assistance to commercial inoculant production (Program 5) *Outreach;*
* Regional resource centers (Program 4) *Outreach*;
* Training *Outreach*;
* Communications *Outreach*;
* Genetic technologies for improvement of Rhizobium-legume symbiosis for crops and trees (Program 1) *Natural Resource Management, Sustainable Agriculture*;
* Development of methods for monitoring microorganisms (Program 2) *Natural Resource Management, Sustainable Agriculture*;
* Environmental and management data collection to maximize performance of

BNF (Program 3) *Natural Resource Management, Sustainable Agriculture.*

Product Development Matrix. A Product Development Matrix was developed and becomes operational October 1993. Each product NifTAL develops will be assigned a Product Development Leader. Their task is to coordinate the project from its conceptualization, design, feasibility study, research and development, testing and finally its distribution to clients. The Leader will access the necessary technical and outreach expertise available within and outside NifTAL.

We expect this approach to accomplish two things: 1) increase the speed at which technologies and products resulting from NifTAL research will be adopted, and; 2) increase the appropriateness and usefulness of technology for the end user. The Product Development Matrix ensures the latest technology is available to the team and this expertise remains focussed and integrated on the end result. Through this structure we intend to maximize discipline integration. An conceptual example of how the Matrix approach spans NifTAL's defined operational programs is in the Figure 1.

Figure 1. Product Development Matrix (to become operational October, 1993).

Product Development Matrix

Strategy for Coordinating Interdisciplinary Research and Development

	Discipline Oriented Programs						
PROJECT	Genetic Resources	Ecology of Organism	Management Systems	Regional Support	Private Sector	Communications	Training
Safti Pak				■	■	■	
Selective Media	■	■	■	■	■	■	■
Elisa Antibody Kits	■	■			■	■	
Micro Production Unit	■			■	■	■	■
Decision Support Systems		■	■	■	■	■	

Program Leader: Expert in discipline - inputs latest ideas and technology into product.
Project Leader: Goal-to move product to market stage.
Accesses and coordinates multidisciplinary team to maintain focus, define responsibilities, and meet time frame.

Infrastructure and Administration. NifTAL maintains its own campus where the activities of headquarter staff are devoted to the AID-NifTAL-Soil Management CRSP. Other staff including those at the University of Hawaii, IRRI, IITA and the Thai Department of Agriculture account for another 5.0 FTE. NifTAL supports six PhD and two MSc students at three different institutions. NifTAL Administration and Facilities Sections manage approximately 35,000 sq. ft. of buildings including laboratory, greenhouse, logistics and training facilities, and 30 hectares of field sites. Fiscal and personnel matters are managed through the Research Corporation of the University of Hawaii with substantial input from NifTAL's Administration section.

Log Framework Output Analysis.

We combined LF planning with a Management by Objectives approach for activities planning and monitoring and reporting output. Table 1 provides a summary of the LF planning exercise.

Table 1. Log Framework Output Analysis: Goals, Constraints, Output Analysis

Core Problem: Population pressures increase export of N from soil systems increasing: 1) reliance on N fertilizer to sustain soil productivity; 2) frequency of unsustainable land management systems resulting from inadequate N supply.

Goal: Develop and transfer improved BNF technologies to enhance N availability in agro-ecosystems.

Constraints:	1) Insufficient use of quality inoculant.	2) Inadequate resident populations of rhizobia in soil.	3) Low legume yields, BNF and conservation of BNF product.	4) Inadequate awareness, information and capacity to exploit BNF technology.
Research/Development Objectives & Activities:				
Improved Inoculant Quality:	Reliable and cost effective quality control and enumeration methods for germplasm collections, industry & soil resource assessment.	Improved survival of rhizobia introduced to soil; Improved plant genetic response to rhizobia resident in soil; Improved germplasm.		
Availability of Inoculant:	Production & packaging technology to lower production cost and ensure product quality.			Promote inoculant production & marketing in private sector; Identify macro-economic factors inhibiting inoculant industry development.
Relevant Management Strategies to Improve Legume Productivity & Conservation of BNF Product:		Management systems that sustain symbiotically adequate populations in soil	Efficient nutrient and resource management; Legumes adapted to sub-optimal environments; Improved management information systems and decision support systems; Efficient cycling of legume BNF product.	
Information, Development Assistance and Human Resource Development:	Investment & production cost information systems. Marketing strategies.	Survey methods and models assessing soil rhizobia resources in farm and agro-ecosystems.		Human resource development in technology, research, extension, and inoculant production; Information on economic and environmental benefits and costs of BNF technology.

Monitoring and Reporting.

The Cooperative Agreement between AID and NCSU specifies quarterly and annual reports related to program progress. In addition, NifTAL will develop quarterly Program Action plans and quarterly review for internal management. The quarterly review process at the Program level will be used to provide NCSU/USAID with the required quarterly progress reports.

Program Activities.

Following are the Program Plans indicating the activities that each program expects to undertake to meet NifTAL's objectives during the next year. These plans include identifying specific clients who will benefit from the Program's output. Integration of activities takes place at the Program level. Methodologies and products developed in the three primarily research programs (Programs 1,2,3) are documented in the Communications Program, incorporated into Training activities, and promoted where feasible for enterprise development by Program 5, and for use in national programs by Program 4. Programs 4 and 5 provide guidance to the research programs at both the planning and execution stage to improve the likelihood products and technologies remain feasible for target clients.

Budget and Resource Allocation.

NifTAL manages several external sources of funds and they are presented in the combined human resource allocation and budget that follows. The budget presented is for 6.12 month period (October 1, 1993 - April 24, 1994) reflecting proven funds allocated to NifTAL during the period April 24, 1993 - April 23, 1994) and the end of our current allocation of AID funds (April 24, 1994).

Impact of Recent Budget Reductions. NifTAL has lost 4.45 FTE in the last year due to budget constraints. These cuts have not been spread evenly across the Programs. Research activities have been reduced to a greater extent than Development Programs. Anticipated cuts in April 1994 will require restructuring NifTAL and eliminating entire Programs.

Many activities of external funds presented in the budget embellish core NifTAL/AID objectives. These sources of funds are prorated to reflect the six month budget period, even though funded for many more years. The budget does not include the substantial leverage of resources by NifTAL and support of NifTAL out-posted staff provided by other institutions such as IITA, IRRI, Thailand Department of Agriculture.

Presentation of extramural funding is to help AID understand the nature of the larger NifTAL program. AID funds from the sub-agreement with North Carolina State University in no manner are co-mingled, compromised or duplicated by this approach.

TIME ALLOCATION BY PROGRAMS INCLUDING UH CONTRIBUTION

October 1, 1993 – April 24, 1994

Enter No. Budget Days in E3 204 6.707 Months

NAME	Program 1	Program 2	Progrm 3	Program 4	Program 5	Admin	Comm.	Facilities	Training	TOTAL % FTE
Abaidoo, R.			0.75							0.75
Amoral, L.								0.90		0.90
Borthakur, D.	1.00									1.00
Carr, T.					1.00					1.00
										0.00
Ekdahl, S.							0.80			0.80
George, T.			0.70	0.15						0.85
Haines, G.	0.10	0.10	0.30		0.15			0.25	0.10	1.00
Hiraoka, S.						0.75				0.75
Hoben, H.									0.80	0.80
Hughes, D.							1.00			1.00
Keane, K.	0.15	0.10	0.50		0.15				0.10	1.00
Keling, B.								0.50		0.50
Keyser, H.		0.30	0.30	0.30					0.10	1.00
										0.00
MacGlashan, K.		0.80								0.80
Martin, B.	0.50	0.30								0.80
Nakao, P.							0.75			0.75
Nikaido, A.						1.00				1.00
										0.00
Rourke, J.		0.20			0.70				0.10	1.00
Scott, P.	0.20	0.20	0.20		0.20					0.80
Sedano–Parrish, B.						0.75				0.75
Singleton, P.	0.05	0.10	0.20	0.05	0.25	0.25			0.10	1.00
Somasegaran, P.	0.25	0.50							0.25	1.00
Boonkerd, N.				0.25						0.25
GRADUATE STUDENTS										
Biotech	0.50									
Linquist, B			0.55							0.55
Lambert, V.			0.50							0.50
Parveen, N.	0.50									0.50
Tewari, S.			0.50							0.50
Zhou*	0.50									0.50
Biotech	0.50									0.50
STUDENT HELP										
										0.00
FTE TOTALS	4.25	2.60	4.50	0.75	2.45	2.75	2.55	1.65	1.55	22.55

*sub cont with UM

Admin.	Month	6.71 Months	% Total
Salary/Fringe	7554	50660	8.7
Supplies	350	2347	0.4
Equip	60	402	0.1
Travel	335	2247	0.4
Utilities	2515	16868	2.9
Total	10814	72525	12.5
Facilities			
Salary/Fringe	3764	25242	4.3
Equip	50	335	0.1
Travel		0	0.0
Facilities Maint.	600	4024	0.7
Total	4414	29601	5.1

Research				Prog-1	Prog-2	Prog-3	General Supplies
Salary/Fringe	36019	241574	43.3	83673	59069	98831	
Supplies	1367	9167	1.6	4472	1341	1677	1677
Equip	0	0	0.0	0	0	0	
Travel	775	5195	0.9	1200	1200	2795	
Subcont./Consult.	1500	10062	1.7	0	7826	2236	
Total	39661	265998	45.7	89345	69436	105539	1677

Development				Prog-4	Prog-5	Training	Commun
Salary/Fringe	27071	181564	31.2	20881	73779	39235	47669
Supplies	1363	9144	1.6	0	2236	200	6708
Equip	292	1957	0.3	0	1118	0	839
Travel	1632	10946	1.9	1500	8385	838	223
Reg Centers	607	4069	0.7	4069			
Subcont./Consult.	917	6149	1.1			6149	
Total	31882	213829	36.7	26450	85518	46422	55439

NOTE: % TOTAL BASED ON ALL BUDGETED FUNDS.

COST BY LINE ITEM/		% Total	6.707 Months
Salary/Fringe	499040	85.8	
Supplies/BNFRC (excl. publ)	15672	2.7	
Admin supplies	2347	0.4	
Equipment	2695	0.5	
Travel	18388	3.2	
Pub'ications	6708	1.2	
Subcont./Comsult.	16211	2.8	
Facilities	4024	0.7	
Utilities	16868	2.9	
TOTAL	581953	100	
OPERATIONS ONLY	82913	14.2	

SOURCE OF FUNDS 6.707 months

	NifTAL	Core	UH Contribution Overhead	Other	MSten	AFNETA	AID/PHIL	NFTA
Sal/Fringe	356273			70047	14986		1118	1650
Res. supplies/BNFRC	20469				0			
Admin supplies	2702							
Public.	10502							
Equip	7042							
Travel	13765							
Facil.	5223		0					
Utilities	6180							0
Subcont./Consult.	11180							
Total	433336	0	0	70047	14986		1118	1650

Source cont. 7 months

Costs	PSTC	USDA/Bio	UH/Grad	FAO/Trn	Lipha/tech	USDA/fruit	Bus/other		TOTAL*	Deficit/ Surplus
Sal/Fringe		9913	9913		4000		4583		472482	−26558
Res. supplies/BNFRC		2236			495				23200	7528
Admin supplies									2702	355
Public.									10502	3794
Equip									7042	4347
Travel									13765	−18196
									0	
Facil.							1118		6341	2317
Utilities							1677		7857	−9010
Subcont./Consult.	2795								13975	−2236
Adjustments to reflect encumbered P.O.'s for forward purchases and balance at April 4, 1993*										
Total	2795	12149	9913	0	4495	0	7378	0	557867	−45187

*Adjustment adds back to Source of Funds line items encumbered P.O.'s for periodic payment obligations in the future that can be cancelled to avoid allocating future expenditures to current budget period. Items include subcontracts, leases, BNFRC salary etc.. etc

Adjustments do not include any balance that is due to teh UH from overhead differential and owed to UH retroactive to July 1, 1992.

Notes: BNFRC budget from Development Division in Program 4 except for Director's salary; Training, communications and Programs 4&5 are part of Development Division budget; Training and Communications support programs in Research divison as well as Development activities; Program 1,2,&3 are part of research budget; fringe is calculated using actual average benefits rather than amount budgeted;

Available funds based on balances of NifTAL/AID/UH accounts as of April 24, 1993; other contracts use amounts committed during period or expected to be encumbered and do not reflect actual balance of funds.

Calculations are net of all personnel that will be paid out of sources of funds during the period.

Overhead is based on 25% of Modified Direct Costs. Current provisonal rate to end by June 1, 1993.

Budget assumes UH contributions to facilites and utilities will remain constant since UH budget is on Jul1 – June 30 fiscal year

DEVELOPMENT ACTIVITIES

Program: **Private Enterprise Development (Program 5)**
CRSP Thrust - Outreach

Program Personnel: T. Carr, coordinator
J. Rourke, P. Singleton

Program Description and Goals

In many developing countries, government institutions have technical and research capabilities in BNF, but these have not been translated into viable industries that can assure delivery of inoculant to the farm gate. Government agencies are frequently involved in inoculant production, and they have been instrumental in the initial introduction of the technology. Lack of incentives and logistical support limits the efficiency and potential growth of these production units to meet quality standards, satisfy potential product demand, and promote market development.

This Program aims to promote and assist private sector investment in legume inoculant production and marketing, and in commercial product/systems development. The clients are the private sector producer and the farmer end-user who benefits from appropriate high quality and readily available inoculant. Assistance to the private sector is the means to the end: to renew farmer confidence in BNF technology by delivering a quality product.

The Program, therefore, concentrates on two main areas: 1) direct private sector assistance; and 2) innovative product development for commercial applications.

Activities

A. Private Sector Assistance

1. Beneficiaries. Private sector assistance requires an integrated program of training, technical and informational services. Training programs for extension specialists, scientists and private company personnel lead to increased farmer awareness, expanded markets, and eventually, conversion to commercial inoculant production.

The main target group for this program are the entrepreneurs and businesses investing in inoculant production in developing countries who receive NifTAL assistance or engage in joint ventures or contracts with American business through NifTAL linkage. American equipment and supply companies and inoculant producers are also targeted as sources of production equipment, supplies, and prepared inoculant.

This program promotes increased awareness and adaptation of quality control procedures internal to production process and external through mandatory government enforced testing. The ultimate beneficiaries will be farmers receiving a readily available, high quality inoculant

product through sustainable commercial production and marketing networks.

2. Activities planned

a. Provide technical assistance, training, backstopping and other necessary services to entrepreneurs and businesses in developing countries interested in investing in inoculant production and marketing operations, and seek necessary funding from AID and other donor sources to cover costs private sector investors cannot economically cover. (Carr; 93/94)

b. Identify technologies and help set research priorities to meet needs of U.S. and other inoculant enterprises.

c. As appropriate, actively promote commercial biotechnology as an attractive business venture via correspondence; news bulletins, annual reports and other publications; field trips, business meetings, conferences, and workshops; and through interaction with the international BNF research community. (Carr; 93/94)

d. Prepare and submit required documentation in response to direct requests for assistance from private companies, international development organizations, international research centers, government agencies in developing countries, and regional research associations. (Carr; 93/94)

e. Prepare ready policy arguments, scientific and economic support data, and other documentation necessary for a fast reactive response to BNF technology inquiries. (Carr, Singleton; Mar/94)

f. Follow-up on proposal and concept submissions to the following countries: Kenya, Uganda, Philippines, Zambia, Bangladesh, Nepal, Sri Lanka, and India. (Carr; 93/94)

g. Monitor closely and be prepared to react decisively to requests for assistance from organizations and projects indicating interest in collaborating with NifTAL including:

Bangladesh: Agribusiness and Technology Support Project

Uganda: On-Farm Productivity Enhancement Support Project

Kenya: Kenya Seed Company

h. Maintain linkages and encourage communication with appropriate contracting agencies, aid organizations, and AID Missions, with the intent to encourage BNF activities to be included in on-going programs, and new project initiatives. (Carr, Singleton; 93/94)

i. Publicize and promote the idea of a regional training workshop for "Legume

Inoculant Production as a Business Enterprise". If appropriate, plan and implement such a workshop(s). (Carr, Hoben; Oct 1993)

j. Maintain present linkage with American inoculant producers and continue to relay overseas trade and investment opportunities as they become known to NifTAL. Continue to inform American and overseas producers what NifTAL products and services are available to them. (Carr; 93/94)

k. Prepare economic impact assessment of USAID investment in Thailand BNF programs (Carr, Singleton, 93/94)

l. Continue to upgrade and publish on a semi-annual basis the data base on international inoculant producers. (Carr, communication; Mar/93)

m. Plan and undertake a field trip to Asian countries to assess the BNF situation in terms of social attitude, food crop priorities, infrastructure, commercial potential, agricultural input usage and supply network, output marketing systems, government policies and ongoing BNF research, facilities and ongoing production of inoculant. (Carr, Boonkerd/BNFRC; Nov/93)

3. Assumptions. Implementation of the action plan is based on the following assumptions:

a. NifTAL will access sufficient AID or other donor funding for outreach programs.

b. LDC government policy does not inhibit transformation of public production operations to private sector.

c. Use of inoculant and commercial production in a country has been justified scientifically and economically.

d. U.S. and foreign inoculant producers are willing and able to assume risk inherent in sole and joint ventures and enterprise development in developing countries.

B. Product Development

This program will continue efforts to develop low cost, efficient systems for quality control, small-scale inoculant production, improved packaging and inoculant delivery systems. Other products include computer software programs to determine economic feasibility of production at the business level and inoculant benefits at the farm level.

1. Program clients.

a. Commercial US and developing country companies interested in innovated cost saving products and applications such as NDF and new inoculant delivery methods.

b. Interested business in LDCs, attracted to inoculant production by low capital requirements of MPU, and ease of production for liquid inoculant.

c. Government policy makers interested in proof of macro-economic, environmental and social benefits of microbiology and BNF.

d. AID Missions and other developmental organizations accessing NifTAL services and products for projects and internal planning.

2. **Products**

a. Software. NifTAL has developed mathematical models based on extensive field experimentation to predict the yield response to inoculation. These models are used in the RESPONSE computer software program. The program has been completed and compiled. A manual will now be published. (Rourke, communications; (Feb/93)

b. Micro-production unit. Low cost MPU modular production systems will encourage business entry into fledgling inoculant industry where demand is low but potential is high. Research and testing of components and production options will continue, and a manual will be published for prospective commercial inoculant production operations. We will be prepared to design and install a MPU facility for a client(s) in 1994. (Rourke, Singleton; Mar/94)

c. Packaging system. Improved inoculant packaging will increase survival of rhizobia and product quality, resulting in enhanced farmer confidence and usage of product. Activities include testing the design of innovative inoculant package systems with inoculant producers, complete patent application. (Rourke, Singleton; 94)

d. Liquid inoculant. Liquid inoculant will attract business entry into inoculant production field where traditional carrier material is too costly or unavailable. We will conduct a preliminary assessment of the feasibility of producing and the performance of liquid inoculant production that can be adapted to the MPU system. (Keyser, Rourke, Singleton; July/94)

e. Fermentor systems. NifTAL-Developed Fermentors (NDF) have been used for successful production of inoculant throughout the world. Research and development in collaboration with Innovative Technology Associates, a local private company now manufacturing NDF units, will continue. R&D should focus on new considerations that arise from the commercial manufacturing process and from the response from the new target market of private sector customers (cost, competition, appearance, durability/ reliability, custom specifications, maintenance, parts, warranties, alternative heat sources, mobility). (Rourke, ITA; 93/94)

3. **Assumptions.** Implementation of this program is based on the following assumptions:

a. NiFTAL maintains linkage with business sector to ensure commercial appropriateness of products and applications.

b. Product/applications are technically feasible and commercially suitable to developing country environmental and infrastructure constraints.

Program: **Regional Resource Centers (Program 4)**
CRSP Thrust - Outreach

Program Personnel: H. Keyser, coordinator
N. Boonkerd

Program Description and Goals

The goal of this program is to enhance the delivery of NifTAL's BNF technology to clients in the developing countries via training, private enterprise development, research collaboration, communications and support services from centers located in strategic points in developing countries.

Regional BNF Resource Centers provide a strong foundation for technology transfer, training and research; assist in establishment and operation of small businesses for production and marketing of inoculant; provide rhizobial cultures and inoculant to industry, researchers and extension personnel; assist regional and national seed and fertilizer projects to increase crop production for food, oil and agroforestry products; design and implement inoculant production and distribution systems; provide technical back-up to USAID missions in the development and implementation of in-country programs; and work closely with PSTC grantees in BNF in the region.

The major clients of this program are the developing country inoculant producers, technicians, researchers and agricultural extension personnel in government and non-government organizations.

Activities

A. BNFRC for South and Southeast Asia

This project continues the successful operations of the BNFRC located in the Thai Department of Agriculture in Bangkok. The BNFRC provides on-going services in the Asia region including training, information and germplasm dissemination, consulting on inoculant production and quality control, and research network development.

B. BNF Action Plan for the Asia Region

Develop an action plan for S and SE Asia in conjunction with several donors active in the region. The action plan will set priorities recommended activities and countries, identifies possible funding agencies for activities, and identifies key people to correspond and meet with for the purpose of developing proposals.

C. Development of Other Resource Centers. We have dropped all plans for another resource center in africa due to budget constraints. We are also uncertain of the role the Centers concept will play in the future CRSP Global Plan.

Training Program
CRSP Thrust - Outreach

Program Personnel: H. Hoben, coordinator
P. Somasegaran, P. Singleton, H. Keyser, T. Carr, K. Keane, D. Borthakur, N. Boonkerd

Program Description and Goals

The training program is a key linkage between NifTAL's research and outreach programs. Its goal is to provide a broad base of scientists, technicians, extension specialists, NGO/PVOs and entrepreneurs with the knowledge and skills to implement legume based BNF technologies in developing countries. Although many countries have adequate research capabilities, they often lack trained personnel in critical areas to implement BNF technologies through extension and industry. NifTAL's training program uses a multi-faceted approach that includes specialized extension and technical courses, a visiting scientist program, post graduate education, and training of dealers of agricultural inputs.

Activities

A. Instructional Materials

1. Training literature. (Hoben, Somasegaran) NifTAL has produced highly respected training literature in the forms of manuals and illustrated concepts. Activities in this area include:

a. Publish second edition of *Methods in Legume/Rhizobium Technology*, to be published by Springer Verlag as *The Rhizobium Handbook.*

b. Write three training publications in the *Illustrated Concept* series.

C. Training Courses

All training courses emphasize "hands-on," interactive learning approaches to supplement traditional instruction. Four collaborative courses are scheduled. Implementation will depend on funding. Tentative schedule:

1. Legume Inoculant Production and Quality Control. Bangkok, Thailand or Los Banos, Philippines, English language. This course targets current and potential inoculant producers in government and industry, and agencies responsible for ensuring quality control of inoculant products. Course contents include general microbiology of rhizobia, mass culture production, carrier and inoculant preparation, quality assurance, strain identification, inoculant application.

2. Legume Inoculant Production as a Business Enterprise. Possible locations include

NifTAL, Hawaii; Los Banos, Philippines; Bangkok, Thailand. The course is for prospective and current legume inoculant producers, entrepreneurs, inoculant production managers. Contents will include inoculation of legumes as a cultural practice, assessing the need for inoculant, large and small scale inoculant production, sources and procurement of equipment, setting up a laboratory and production plant, economics of inoculant production, marketing and handling of inoculant.

4. Applied Legume BNF Technology for Extension Specialists. Course available on request, duration one to two weeks. The course is for government, Peace Corps, PVO/NGO extension specialists. It emphasizes practical aspects of BNF technology, and methods and materials for the specialists to transmit the technology to farmers and other extension agents.

D. Collaborative Training

Many aspects of NifTAL's training program are a result a successful collaboration. Various institutions and organizations are approached to develop joint training activities and proposals. This ongoing activity will be intensified this planning year. This type of collaboration can take many forms, from full partnerships to buy-ins and limited participation in each other's training events or program. The collaboration serves to increase the breadth of the audience receiving training in BNF, to integrate BNF into other disciplines and programs, and to leverage training resources. Likely collaborators include NFTA, IFDC, Mississippi Seed Project, PVO's Winrock, FAO, IAEA, and CGIAR's.

E. Visiting Scientist Program

This is an on-going program for self-supporting scientists who wish to do research at NifTAL and learn new techniques. Two visiting scientists are anticipated at the NifTAL headquarters in Hawaii, and two are anticipated at NifTAL's BNF Resource Center (BNFRC) in Thailand.

F. Graduate Training Program

NifTAL's graduate program supports MSc and PhD candidates who develop research projects in the area of BNF. The students are enrolled at the University of Hawaii or collaborating institutions. NifTAL will be supporting six PhD and two MSc candidates. The students are from USA, Ghana, Trinidad, Guiana, China, India, Indonesia.

G. Training Impacts

NifTAL will improve its data base of previous NifTAL trainees and conduct a survey to assess the long range impact of their training.

Communications Program
CRSP Thrust - Outreach

Program Personnel: S. Westley, coordinator; P. Nakao, coordinator from March 1, 1994
D. Hughes, S. Ekdahl

Program Description and Goals

NifTAL's Communication Program supports the linkage between NifTAL and its clients throughout the world. There are three major areas of activity:

1. Transmit information on NifTAL and NifTAL-developed technologies to potential beneficiaries: NifTAL's Communications Section facilitates the transfer of BNF technology by packaging information as appropriate to our clients' needs. We produce newsletters, manuals, promotional materials, and other informational resources to support NifTAL's training, outreach, and research programs. We also respond to approximately 500 requests for articles, technical information, and manuals per year.

2. Provide required information to USAID, institutional collaborators, and administrators: NifTAL is linked to numerous agencies and institutes for funding, administration, management, and collaboration. The Communications Section supports NifTAL efforts to meet proposal and reporting requirements.

3. Maintain and improve informational resources: We maintain a library and database of scientific, resource and institutional documents for NifTAL staff and clients in industry, extension, education, and research.

We anticipate significant changes in this section. The merger of the NFTA and NifTAL Communications efforts will end when NFTA relocates to Arkansas in early 1994. This section has lost editorial and document management assistance with the recent budget adjustments and services to both NifTAL staff and to clients overseas will be reduced.

Activities

A. Facilitating BNF Technology Transfer

1. Products. The Communications Section will provide technical writing and/or editing, graphics and layout for the following. Publication/completion is expected unless indicated.

a. Second Edition of *Methods in Legume-Rhizobium Technology* by Somasegaran and Hoben.

b. Revised manual *Applied BNF Technology: A Practical Guide for Extension*

Specialists. Publication in more economical format expected.

c. Revised manual *Standardized Protocols for Field and Greenhouse Experimentation in Legume BNF.*

d. Two *Illustrated Concepts in Agricultural Biotechnology.*

e. Manual *Legume Inoculant Production.* Edited draft ready for publication expected.

f. Manual for RESPONSE software.

g. Operations manuals and technical brochures for *NifTAL Fermentor Systems: NDF-20L* and *NDF-100L.*

h. Condensed germplasm catalogue *Recommended Rhizobial Strains for the Production of Legume Inoculant.*

i. Resource directories: *BNF Country Profiles*, *Directory of BNF Resource Persons*, and *Directory of Inoculant Producers.*

j. Two issues of the *BNF Bulletin* and *Continuing Bibliography* insert.

k. Brochures: RESPONSE Model
BNF and Environmental and Economic Issues

l. Scientific publications for NifTAL staff.

m. Scientific and promotional posters.

n. Slide presentations and narration on NifTAL, impacts of BNF. Assembly of materials and drafts expected.

o. Video on NifTAL capabilities, initiate contacts and storyboard.

2. Distribution of publications.

a. *BNF Bulletins* and *Continuing Bibliographies* will be distributed biannually to approximately 1800 readers in 100 countries. Mailing list will be updated.

b. Other publications will be distributed as appropriate and on request.

B. Administrative Reporting

1. Reports/proposals to funders and host institutes. Annual, quarterly reports and plans

to meet TropSoils and USAID requirements will be prepared. This section will assist preparation of TropSoils proposal and provide documents for University of Hawaii, Research Corporation, etc., and other reports and documents as required.

C. Informational Resources

1. Library. Communications section will maintain and update library and document collection. Staff services include review of current publications, provide custom citation lists, and order documents. Library produces a biannual BNF bibliography insert for *BNF Bulletin*, and assembles bibliographies for clients on request.

2. Informational databases. Informational databases will be maintained and updated for BNF document collection, BNF resource persons, inoculant producers, and former trainees. Surveys will be conducted to update these resources. Published outputs are mentioned above.

RESEARCH ACTIVITIES

Program: Genetic Technologies for Improved BNF (Program 1)

Program Personnel: D. Borthakur, coordinator
P. Somasegaran, B. Martin, N. Parveen, S. Mukthar, Z. Zhou

Program Description and Goals

The goal of this program is to produce rhizobia with enhanced performance in either inoculant, seed, soil, or symbiosis. Our approach is to identify priority and appropriate genetic characteristics and specifications relevant to agriculture and industry; describe the molecular basis of genetic characters; field test in relevant, defined environmental conditions; make germplasm available to end users; monitor and measure impact. A significant portion of the research activities are supported by extramural funds. Activities developed in these areas will be coordinated with other relevant NifTAL programs.

Program activities include the maintenance, preservation, and distribution of *Rhizobium* germplasm, collection and evaluation of new strains, selection of the best strains for different environments, and genetic improvement of selected strains. This program focuses on the immediate needs of the inoculant producers and farmers, although some attention is given to the demand for certain types of strains in the future.

The major clients of this program are the inoculant producers, farmers, and researchers in developing countries. Many researchers working in the field of nitrogen fixation in the US universities and other countries will also benefit from this program. *Rhizobium* germplasm from NifTAL is used in many research institutions (IARCs, NARSs) and by inoculant producers around the world. The Department of Microbiology, Indian Agricultural Research Institute, New Delhi, which is the headquarters of the BNF program in India, will also benefit from the graduate training component of this program.

Activities

A. Competition Factors

1. Genetics of nodulation competitiveness in *Rhizobium leguminosarum* bv. *phaseoli*. (Borthakur) Competition for nodulation between indigenous rhizobia and superior inoculant strains if often a constraint to realizing a benefit from inoculation. While competition is a complex problem involving the host, microsymbiont, and their interaction with the environment, it is important to pursue those factors that are genetically controlled to evaluate the feasibility of overcoming competition through genetic manipulation. TAL182 has been identified as an effective and competitive strain for common bean. We have identified a 25 kb region of DNA from the third largest indigenous plasmid of this strain that contains genes involved in nodulation competitiveness. By using this piece of DNA for site-

directed mutagenesis, we have isolated two mutants of strain TAL182 which are defective in nodulation competitiveness. Actions:

a. Continued characterization of subclone various DNA fragments within the 25 kb region.

b. Identify fragments containing gene(s) for nodulation competitiveness.

2. The relationship of mimosine catabolism by *Rhizobium* sp. (*Leucaena leucocephala*) with nodulation competitiveness in the rhizosphere. (Borthakur) Mimosine is an unusual amino acid present in the leucaena tree and is toxic to bacteria and animals. We have recently found that only about one-third of *Rhizobium* strains that nodulate leucaena can catabolize and utilize mimosine as a sole source of nitrogen. No other rhizobia or bradyrhizobia tested so far can break down mimosine. We hypothesize that these strains that can utilize mimosine as a source of nitrogen may be more competitive in the rhizosphere. Actions:

a. Screen the entire NifTAL collection of rhizobia for tree legumes for their ability to utilize mimosine.

b. Conduct a competition experiment using mimosine-resistant and mimosine-sensitive strains.

c. Isolate mimosine-sensitive mutants from the mimosine-resistant strain TAL1145 and test these mutants against TAL1145 in competition experiments.

B. Maintenance and Improvement of NifTAL *Rhizobium* Germplasm Collection.

1. Germplasm collection. (Martin, Somasegaran) NifTAL maintains one of the largest and most active collections of tropical rhizobial germplasm. This collection continues to be an important source of inoculant quality strains for producers and researchers around the world. As a *Rhizobium* MIRCEN, the collection is also a repository of valuable and unique strains for use in training and testing through the network of other MIRCENs world-wide. Maintenance of a quality collection requires acquisition of new strains for important new legumes (e.g. trees) or strains possessing unique characteristics (e.g. high temperature tolerance) from other sources (germplasm collections and individual scientists).

a. Identify a priority group of candidate legumes for which we will then acquire their rhizobia from other known sources, preferably evaluated and recommended strains;

b. Supplement our collection with strains tolerant to high temperature, desiccation, acidity, or possessing high competitiveness or other symbiotically desirable attributes. Document strain characteristics in collection data base.

c. Continue distribution of germplasm on request.

d. Publish a condensed germplasm catalogue listing recommended strains for inoculant production.

C. Exopolysaccharide (EPS) Production

1. Genetic control of exopolysaccharide (EPS) production in leucaena *Rhizobium*. (Borthakur) Studies on other fast-growing rhizobia have shown a relationship between EPS mutants and defects in nodule development. EPS may be a signal or structural component for infection thread formation, play a role in host response, or play a role in maintenance of the bacteroid within the nodule. The relationship of these phenotypes is not understood, and no work has been done with leucaena rhizobia.

We have also started an in-depth study of the EPS characteristics of the leucaena-*Rhizobium* TAL1145 and isolate genes involved in EPS synthesis and required for nodulation. Several mutants have been isolated defective in both EPS synthesis and nodulation of leucaena and beans. Two cosmid clones that complement one such nodulation defective mutant have been isolated. Actions:

a. Characterize genes for EPS synthesis contained in these cosmids and determine their function in symbiosis.

b. Screen the NifTAL leucaena-*Rhizobium* collection for various colony morphology and exopolysaccharide (EPS) characteristics to determine the relationship of EPS characteristics with infection process, and other saprophytic characteristics such as acid and temperature tolerance.

Program: Methodologies for Monitoring Microorganisms (Program 2)

Program Personnel: P. Somasegaran, coordinator
H. Hoben, H. Keyser, K. Keane, B. Martin, K. MacGlashan, T. Scott, P. Singleton, M. Sadowsky, Z. Tong

Program Description and Goals

Our ability to monitor or detect rhizobia in soils, inoculant, and in root nodules is of paramount importance to determine the success of introducing exotic inoculant strains of rhizobia into crop systems. The maintenance of inoculant quality is a significant constraint to delivering legume BNF technology to farmers. NifTAL has found that many inoculant produced around the world do not contain rhizobia.

Researchers, culture repositories, US and foreign commercial inoculant producers, and agencies monitoring inoculant quality require feasible, improved, rapid and reliable methods to monitor rhizobia. Host and rhizobial genetics as well as many environmental, physiological, economic, and human resource constraints limit the use and reliability of existing technology to monitor rhizobia. The goal of this program is to address these constraints to develop improved methods for monitoring the fate and performance of microorganisms in inoculant and the environment. To support NifTAL's new emphasis on private sector development, this program will focus on inoculant production and distribution needs. Application of methods developed in this program can be found in all other NifTAL Programs.

Activities

A. Develop Improved Quantitative Methods for Enumerating Rhizobia Populations in Inoculant and Soil.

1. Plant infection. (Somasegaran) Enumeration of rhizobia in non-sterile matrices like soil or batch-inoculant requires indirect estimates by Most-Probable-Number (MPN) plant-infection procedures. Many standard MPN methods require specific supplies and environmentally-controlled plant growth facilities for accurate enumeration. These resources are generally not readily available in developing countries. The lack of precision of MPN results in collaborating developing country labs has been a major constraint in earlier NifTAL networks.

We will begin to test this new systems developed in 1993 with our Product Testing Network, write protocols for publication and disseminate the technology for soybean and common bean. We will continue activities to develop low cost, more reliable MPN methods using the germplasm of small-seeded species chickpea (*Cicer arietinum*), peanut (*Arachis hypogaea*). These other small-seeded varieties may also be tested outside NifTAL if they prove satisfactory.

2. Selective media. (Tong, Sadowsky, University of Minnesota) We will continue

collaborative activities with the University of Minnesota to develop selective plating media, based on combinations of metal salts, for the detection and enumeration of rhizobia in soil and in inoculant produced with non-sterile carriers. Reliable selective media for rhizobia will greatly reduce the costs of quality control procedures for inoculant producers. A selective medium has been developed for alfalfa rhizobia and soybean. One other species will be targeted for development and the soybean media will enter into a testing program with inoculant producers.

4. Antibody methods. (Keyser) Development of polyclonal antibody kits that use the immunoblot (ELISA) technique. The immunoblot procedure are nearing completion. These are a reliable serological method for the identification of rhizobial strains. We will finish specifying a complete standard kit to rapidly identify rhizobia (e.g. soybean rhizobia) within target serogroups. The method involves the reaction of mixed species-specific antisera with an enzyme that results in color development on paper. We will work with inoculant producers to test the kit for results consistency, storage life and utility.

A genus-specific immunoblot method will also be tested for use in a kit as described above. Genus-specific internal antigens will be developed and tested for suitability in recognizing *Rhizobium* and *Bradyrhizobium* species. Kits will be evaluated for usefulness and cost effectiveness in NifTAL's Product Testing Network. Depending on the results, a manufacturer will be sought to market the kit to inoculant producers and quality control agencies

B. Application of Technology

1. Needs assessment. A survey will be conducted of the needs and capabilities of inoculant producers for quality assurance and strain maintenance technology through the Directory of Inoculant Producers that has been compiled.

2. Information dissemination. We will develop a plan in conjunction with the BNF Resource Centers and Communications and Training Programs, and Product Testing network to disseminate and implement promising technologies.

Program: **Environmental and Management Data Collection to Maximize the Performance of Biological Nitrogen Fixation (Program 3)**

Program Personnel: B. Linquist, coordinator
P. Singleton, H. Keyser, T. George, S. Tewari, V. Lambert, R. Abaidoo

Program Description and Goals

The ultimate goal of this program is to identify comprehensive, sustainable land management strategies that meet the demands for enhanced soil productivity and the conservation of natural resources. The contributions of biological nitrogen fixation by legumes to sustainable agro-ecosystems are integral to this goal. This program emphasizes the environmental and management impacts on symbiotic performance or the fate of symbiotic products.

The objectives of this program are:

1) identify microbial, environmental, and management constraints to legume productivity and subsequent fixed nitrogen inputs into cropping systems;

2) evaluate and develop management strategies for legumes to overcome identified performance constraints;

3) synthesize information from research activities to assist crop model and decision support systems development for legume management.

Through collaborative linkages, this program is highly integrated with the goals of crop modelers, international agricultural centers, and researchers in US and foreign universities. Information synthesis will support *Simulation and Decision Support System* developers (presently those at IFDC and Universities of Hawaii, Georgia, and Florida), IRRI, IITA, and the Thai Department of Agriculture.

Ultimately extension agents, breeders, and policy decision makers will benefit from improved precision of these systems. Specific activities within this program are directly integrated into other USAID supported programs. In particular IITA and IRRI will immediately benefit by improved recommendations to national programs about management of BNF and release of improved legume varieties with enhanced BNF.

Activities

A. Identification and Alleviation of Constraints to Legume Productivity and Nitrogen Fixation

1. Increase legume host range in IITA Grain Legume Improvement Program (GLIP) across four different climatic zones in Nigeria. (Abaidoo, collaboration with IITA, Keyser, Singleton) In Africa, legume yield and nitrogen fixation can potentially be increased without inoculant inputs. GLIP's approach is to breed legumes with a broader host range for effective nodulation with native rhizobia. For breeders to identify genes that will develop full expression of BNF with indigenous rhizobia in farmers fields, it is imperative the native populations be characterized and plant material selected in the appropriate background of indigenous rhizobia. We continue this collaborative work through staff posted at IITA. We will eliminate this position at IITA as of January 1994.

a. Analyze results from second year's field experiments.

b. Characterize indigenous cowpea isolates physiologically.

c. plan future work to identify genes (in conjunction with Program 1) of host and microorganism that control the full expression of BNF by indigenous strains.

2. Nitrogen fixation and productivity of nitrogen fixing trees on acid soils as affected by phosphorus and calcium. (Lambert, collaboration with University of Hawaii, keyser, Singleton) Most forestry and agroforestry are inherently low input systems. Tolerance of soil stresses and use-efficiency of soil nutrients by nitrogen fixing trees (NFTs) are critical to their growth and the amount of N they can add to the systems. In weathered soils, use-efficiency of P under acid conditions will be the primary determinant of tree performance. This research has three goals:

a. Develop selection criteria for trees with improved performance in low input agroforestry systems of the upland tropics by identifying mechanisms by which trees tolerate low P conditions.

b. Identify strategies for enhanced performance and nitrogen fixation by NFTs with reduced inputs.

c. Develop cost effective management solutions to overcome soil constraints associated with soil acidity.

Activities:

a. Complete field study in acid soils to evaluate the response of selected species to variations in P availability.

B. The Role of Legumes in Cropping Systems and their Management to Maximize BNF

1. Conservation and use of soil and legume-fixed N in lowland rice-based cropping systems. (George, collaborators IRRI, IFDC) Approximately 90% of rice land in Asia is in the lowlands. There is large nitrate accumulation in these soils during the dry season. At the onset of rains this nitrate is lost to the system through leaching and de-nitrification. Weedy and managed fallows between rice crops can capture the nitrate for use by the succeeding rice crop when the plant material is tilled in. Dry season fallows with legumes offer the dual opportunities to conserve existing soil N plus add N to the system via BNF.

This research with IRRI has developed N balances through the cropping systems, and evaluated the advantages of growing legumes on the residual soil moisture between rice crops. Enhancing the conservation of soil N and increasing N input through BNF will reduce farm production costs with less impact on groundwater quality. Two journal articles will be submitted.

2. Long term experiments on the cumulative and residual effects of applied P fertilizer on legume productivity and nitrogen fixation, P availability and dynamics, and the contribution of fixed nitrogen to subsequent crops. (Linquist, collaborators UC Davis, IRRI, IFDC, U of Hawaii) Phosphorus is the most limiting nutrient to legume productivity and nitrogen fixation on the highly weathered soils of the upland tropics. These experiments allow us to develop cost effective management strategies for P fertilizer and to understand how these strategies affect nitrogen inputs and cycling in the system. Results have indicated that current soil tests are inadequate to predict the availability of residual P from previous P inputs. We will analyze several soil characteristics including the influence of aggregate size and its effect on P flux as a mechanism that affects P bio-availability. These parameters will be evaluated for their contribution to the precision and efficiency of the *Phosphorus Decision Support System* (PDSS) developed by TropSoils, and to support the IFDC's development of a phosphorus submodel for legume growth models.

Work plan:

a. Write paper describing the dynamics of inorganic and organic P-pools in long term management experiments. Identify pools that are indicators of crop productivity that can be used to enhance the precision of PDSS.

b. Determine soil organic C and N in relation to P availability and nitrogen fixation.

c. Determine the influence of aggregate size on P flux and bio-availability. Determine whether some simple measures of soil physical properties are useful indicators of residual P-availability.

d. Submit two journal articles.

e. Provide PDSS and LeGro systems developers with soil, plant, and BNF data.

f. Provide IFDC with data from NifTAL's extensive, long-term field experimentation. The samples will be used to validate IFDC's P tests for indicating P fertilizer need.

3. Phosphorus, carbon, and nitrogen dynamics in Asian upland agro-ecosystems. (George, collaborators IRRI, IFDC) The most frequently encountered management problem in tropical uplands is P deficiency. Most upland agro-ecosystems are not sustainable without external P inputs. Presently, crop yields are low in these systems and fertility continues to decline. Phosphorus has synergistic and complementary effects on nitrogen and carbon cycles and nitrogen fixation; however, the quantitative relationships between P addition and P availability to crops over time is poorly understood. This research is designed to evaluate economically rational management strategies for the upland of Asia. Plans include collaboration on the research design and conducting field studies.

C. Information Synthesis

1. Improving legume growth models (LeGRO) and its nitrogen and phosphorous sub-components. (Tewari, collaborators IFDC, IBSNAT, U of Georgia, U of Florida, U of Hawaii) Generation of theory for partitioning of dry matter and nitrogen above and below ground under different nitrogen regimes for different legumes will improve the precision of the LeGRO simulation model. Improved decision support capabilities will assist managers, extension personnel, researchers, and breeders. Work plan:

a. Complete simulation for initial field experiment.

b. Analyze field data form 1993 season on additional legumes and begin analysis.

c. Submit one journal article.

2. Modeling dynamics of rhizobia in tropical cropping systems. (Singleton, collaborators Thai Department of Agriculture, BNFRC, Khon Kaen University) The goal of this research is to achieve a quantitative understanding of the effects of soil, climate, and management on rhizobial populations, and how inoculant influence legume performance in these contexts. Models generated from these data will allow planners and entrepreneurs to develop and promote legume inoculant in markets with the greatest potential benefit. Work plan:

a. Analyze data from 96 farms for the 92/93 crop season.

b. Input weather and soil data into data base.

c. Coordinate data acquisition and initial model validation with IFDC.

d. Develop reference models describing the seasonal fluctuations of rhizobial populations in relation to management, soil, and climatic factors.