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Executive Summary Report

Program Year Ten
1990–1991

TropSoils
The Soil Management Collaborative
Research Support Program

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The Soil Management Collaborative
Research Support Program

Management Entity Office
North Carolina State University
Raleigh, NC 27695-7 13

Collaborating Organizations

U. S. Government

United States Agency for International Development
Bureau of Research and Development

Board of International Food and Agriculture Development
Joint Committee on Agricultural Development

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M. Ray Smith	University of Hawaii
Eugene J. Kamprath	North Carolina State University
E. C. A. Runge	Texas A&M University
Jan van Schilfgaarde	USDA-ARS
Robert R. Shaw	USDA-SCS

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I. EXECUTIVE SUMMARY

The 1990-91 program year was year ten (10) for the Soil Management CRSP (TropSoils) and year two (2) of the present grant extension. This was also a year of many programmatic and operational changes being completed and put into place.

It was purposed by AID/R&D that programs in soil and water management be merged to better utilize these capabilities. This would merge the activities of Soil Management Support Services (SMSS) of USDA-SCS and Technology for Soil Moisture Management (TSMM) of USDA-ARS and USDA-ERS with those of TropSoils. This was approved by JCARD and BIFADEC and a new grant issued for the period July 28, 1991--September 24, 1994. New university subgrants were established and subagreements between North Carolina State University as the ME and USDA/ARS, USDA/ERS and USDA/OICD were put in place. The 1991-92 annual work plans and budgets reflect this merger. This merger has brought Drs. Jan van Schilfgaarde (USDA/ARS) and Dr. Robert R. Shaw (USDA/SCS) to serve on the Board and Drs. John Day (USDA/ERS) and Hari Eswaran (USDA/SCS) to serve on the Technical Committee.

Twenty (20) percent funding increase was received in mid-year from which new initiatives have been started in cross-cutting programs and collaborations in Honduras, Bolivia, Philippines and Togo. Funds were also allocated to initiate collaboration in Cameroon and strengthen interCRSP activities in Honduras, Niger, Burkina Faso and other potential locations.

The Board of Directors moved to close out special funding to maintain primary research sites. All primary research site fundings are now ended with Hawaii moving to the collaborative mode in Indonesia, North Carolina State University supports a coordinator from projects in Peru and Texas A&M supports their site coordinator from a special watershed development buy-in grant from USAID/Niamey Mission.

Travel restrictions from January 16, 1991, through May 15, 1991, delayed some overseas travel and delayed opportunities. The humid-tropics socio-economic impact grant activities were most affected by these travel restrictions.

In addition to expanding the Technical Committee, there were some changes during the past fiscal year. Dr. T. Jot Smyth replaced Dr. Pedro A. Sanchez upon his mid-year retirement from North Carolina State University. Mr. Timothy McBride replaced Neil Caudle as coordinator of the Communications Program.

With the move away from primary sites to manage more effective cross-cutting programs, TropSoils has established working agreements with ICRISAT, Universidad Nacional in Costa Rica, ORSTOM in France and Panamerican School in Honduras. A

memorandum of agreement with the Government of the Republic of Cameroon, with Cornell University as the lead institution, was signed into effect. An addendum to the memorandum of understanding with IRRI was finalized to establish the graduate student protocol. The move away from primary site operations was precipitated by some Missions not wanting CRSPs in their country and continued uncertainty of AID status of other countries of operation.

Eleven graduate students (six Ph.D. and five M.S.) completed their degrees under the TropSoils program during 1990-91. There are 17 (14 Ph.D., three M.S.) candidates presently in the program. Twenty referred manuscripts were published, 20 special and miscellaneous reports, 25 papers and posters presented and 26 special request program participation responses were honored, all during 1990-91. The scientists in TropSoils serve on many national and international steering and policy committees that provide long-range direction to the management of soil and water resources for sustainability.

II. THE CONCEPT OF THE SOIL MANAGEMENT CRSP

To promote long-term solutions to world famine by bringing U.S. technical expertise to focus on resolving problems of food production constraints, the U.S. Congress passed the International Development and Food Assistance Act of 1975. Included in the act was "Title XII--Famine Prevention and Freedom From Hunger" that states "...in order to prevent famine and establish freedom from hunger, the U.S. should strengthen the capabilities of the U.S. land grant...universities in program-related agricultural institution development and research... improve their participation in the U.S. government's international efforts to apply more effective agricultural sciences to the goal of increasing world food production, and in general should supply increased and longer-term support to the applications of science to solving food and nutrition problems of the developing countries.

Natural resources, with soils as the foundation, are the long term capital on which nations build and grow. Every country has an endowment of soil, water, mineral, plant, and animal resources. If the quality of life of its inhabitants is to be improved and sustained, it must be a good steward of these resources. Catastrophic consequences have beset those prior civilizations that allowed degradation of their natural resources beyond the levels necessary to sustain them. Similar processes are in progress today in many of the underdeveloped and developing countries.

Because capital inputs are strongly limiting in under developed and developing countries, the nature, quality, and distribution of land resources strongly govern utilization of

land for agricultural production. For this reason, the most efficient integration of indigenous cultivator knowledge into research programs is via a knowledge of the constraints and potentials of soil resources as perceived by farmers. Subsequent cataloguing of this information with baseline soil characterization and classification systems provides the best avenue for rapid assimilation of new technology by farmers. This integrated approach to technology assimilation for transfer on a Land Management Unit basis also serves for extrapolation of this information to other developing regions having similar soils and socio-economic structures.

III. SOIL MANAGEMENT GOAL AND GLOBAL PLAN

The goal of the Soil Management CRSP is to develop and adapt improved soil-management technologies that are agronomically, ecologically and economically sound for developing countries in the tropics. To accomplish this goal the Soil Management CRSP has focused its research thrusts the major constraints to sound Natural Resource Management, Sustainable Agriculture Production and Outreach. As the process research has progressed by generating appropriate technology for Natural Resource Management and Sustainable Agricultural Production, the Outreach thrust serves as the transfer activity working integratively on basic Land Management Units.

A. SUSTAINABLE AGRICULTURE PRODUCTION - The successful management of resources for agriculture to satisfy changing human needs while maintaining or enhancing the natural-resource base and avoiding environmental degradation.

1. Soil Acidity - Most soils in the humid tropics are very acid, low in exchangeable bases, and high in exchangeable aluminum. The acidity and toxicity of these soils constrains agricultural productivity in several ways. Sensitivity of plant species and cultivars to soil acidity and associated problems limits crop production. Technologies to ameliorate soil acidity are paramount on most tropical soils.

2. Nutrient Deficiencies and Losses - Soils in the humid tropics are often low or deficient in one or more primary and secondary plant nutrients. Low crop yields attributable to poor nutrition and accelerating soil degradation are major contributors to land abandonment and continuous rainforest destruction. Biological perspectives and nutrient cycling knowledge is necessary for sustainable systems.

3. Soil Physical Limitations - Soils of the tropics are characteristically highly weathered and, because of climate and other natural factors, are variable in organic matter. The overuse of traditional management systems often leads to soil physical degradation, land abandonment and rainforest encroachment.

4. Topographic Limitations - Landscape configurations impose special challenges in the development of appropriate soil-management technologies. Humid tropical soils of the steep lands are especially vulnerable to degradation as a result of water erosion. Selection of crops, cultivars, cropping sequences, and crop mixtures without considering landscape configurations often results in a loss of food and fuel production. Some landscape should best not be disturbed.

5. Water Stress - Moisture stress, natural or imposed, may result from either excessive or inadequate amounts of water. Selections of the best ecologically adaptable and socially acceptable combination of crop, plant species, cultivars, and cropping sequences are necessary production management and must be decisions tempered by experience, financial constraints, and risk assessments.

B. NATURAL RESOURCE MANAGEMENT - The management, conservation, and enhancement of those natural resources which are most critical to meeting food, fiber, fuel and shelter requirements, as well as preserving genetic diversity and attenuating climatic change.

1. Land-Clearing Pressure - Population growth in the tropics places extreme pressure on the soil resources. As the number of farms increases, fallow periods are shorter, and vital nutrients are lost from the soil. Farmers must clear more land to grow the same amount of food. Countries with high populations have little under-used land available.

2. Landscape Restrictions - Even on rolling and gently sloping tropical landscapes, wind and water erosion may be common. Without reliable information about natural processes, it is impossible to formulate sound management practices.

3. Climate Variability - In regions where rainfall or temperature are extreme, climate can be a major factor in soil management. Climate influences the physical, chemical and biological properties of soils, as well as the choice of cropping system.

4. Inadequate Resource Information - Policies to achieve sustainable agriculture production must be based on an adequate technical assessment of natural resource inventory. These inventories are often incomplete or not available. Almost no reliable information exists on how forest conversion effects soil dynamics. Inventory of indigenous technologies should be included with physical inventories.

5. Production--Demand Pressure - Population growth, accompanied by increased demand for food, fiber, fuel and shelter

materials, places extreme pressure on the soil resources. Larger and larger areas must be brought into production to meet the demands for food and exports. Soil resource inventories are needed to plan and develop export crop policies.

C. OUTREACH - Those extrapolations, communications, training, networking, and decision-support activities which translate research into useful knowledge.

1. Number and Diversity of Users - People throughout the developing world lack appropriate soil-management technologies. They are diverse in their needs, languages, and cultures. Extension and communication channels in developing countries are rudimentary; ethnic, cultural, and linguistic barriers are common.

2. Number and Diversity of Soils - To be effective, soil-management practices must accommodate a range of conditions, including soil chemical and physical processes and crop and cultivar; climate and landscape; and social and economic conditions. While certain soil-management problems are common to many sites, solutions appropriate for one location may be inappropriate for another.

3. Lack of local Expertise, Information - The lack of trained soil scientists, agronomists, educators, and communicators in developing countries impedes the transfer and adoption of new agricultural technologies. Training and education provided by the Soil Management CRSP degree programs, workshops, and field projects contribute significantly to the base of soil-management expertise in the developing countries.

4. Information Knowledge Gap - Traditionally, research results become scientific knowledge through a lengthy process of consensus-building that includes peer review, publishing, public comment and application. In developing countries with degraded and degrading soils rapid application is important to stabilize the natural resource base while developing sustainable agriculture production. Decision Support Systems and Geographic Information Systems offer effective means to capture new technologies that can be integrated with indigenous technologies for transfer onto small watersheds or Land Management Units.

5. Lack of Skills & Research Capability - A constraint to Natural Resource Management and Sustainable Agriculture Production in developing countries is the shortage of trained professionals to implement appropriate policies and programs. The Soil Management CRSP has the Institutional strength to provide education, training, backstopping and broad based support to Natural Resource Management and Sustainable Agriculture Production.

IV. SOIL MANAGEMENT CRSP OPERATIONS

A. Agroecological Focus

While developing nations in the tropics share common constraints to Natural Resource Management, Sustainable Agriculture Production and Outreach, these constraints manifest themselves in varying ways from region to region. The operational strategy employed is to structure the operations along the following agroecological zones.

1. Humid Tropics - This is the portion of the tropics where there is no more than a three-month dry season and temperature is not a limiting factor to plant growth. The native vegetation is tropical rainforest. Soil Acidity and nutrient deficiencies are common chemical constraints to crop production.

2. Semiarid Tropics - This zone is characterized by a protracted dry season of six to nine months. Erratic precipitation, wind and water erosion, desertification, soil acidity and nutrient deficiency are major constraints to crop production.

3. Savannas - This portion of the tropics is characterized by a strong dry season of four to six months, savanna vegetation and predominantly acid soils with inherently low nutrient levels but generally good physical conditions. Temperature is not a limiting factor to plant growth.

B. Research Program Operations

The research activities during the 1990-91 fiscal year concentrated in the agroecological zones and countries:

Humid Tropics - Peru, Indonesia, Costa Rica, Philippines, Bolivia, Togo
Semi-Arid Tropics - Niger, Mali, Honduras
Savannas - Nigeria

Following the decision by the Board of Directors to move away from maintaining prime sites, collaborative activities were initiated with institutions and countries new to TropSoils.

The collaborating institutions during the 1990-91 fiscal year were:

Costa Rica - University of Costa Rica

Peru - Instituto Nacional de Investigacion Agraria y Agriondustrial (INIAA)

Honduras - Ministry of Natural Resources (MNR-LUPE Project)

Indonesia - Center for Soils and Agroclimatic Research (CSAR)

Niger - Institut National de Recherches Agronomiques du Niger (INRAN)

Bolivia - Ministry of Agricultural and Farmer Affairs (MACH)

Mali - Institut d'Economie Rurale (IER)

Nigeria - International Institute for Tropical Agriculture (IITA)

Philippines - International Rice Research Institute (IRRI)

Togo - ORSTOM and National Soils Institute (INS)

C. Outreach Program Operations

1. Network

The Latin American network, "Red de Investigacion de Suelos Tropicales" (RISTROP), initiated under extramural grant is being brought under some core funding support. There are about 12 Central and South American countries active with over 20 institutions plus International Agriculture Research Center active in the network. North Carolina State University offers program coordination and technical backstopping to the project.

2. Integrated Management of Agricultural Watershed (IMAW)

The implementation phase, through grant direct from the USAID/Niamey Mission to Texas A&M University was consummated with two (2) years of funding. The IMAW project is now in the stage of implementation. The two (2) reports from the feasibility study have been completed and are being distributed. A companion project to monitor the role of women and their potential change in the watershed area was also approved for Mission funding. The newly merged TropSoils/TSMM economics component is now establishing a collaborative program with INRAN/DECOR to include this activity into the project.

3. New Agreements Established

Changes in host country politics, mission policies, demand-driven needs and request by the Technical Coordinators and Board of Directors has led to establishing new collaborative agreements.

A memorandum of agreement, with Cornell University

as the lead institution, was signed on July 22, 1991. Memorandums of understanding have been signed with 1) Universidad Nacional of Costa Rica, 2) International Center for Research in the Semi-Arid Tropics, 3) Panamerican School, Honduras, and 4) ORSTOM of France. Other agreements and working agreements are expected to be finalized during the 1991-92 fiscal year.

V. SOIL MANAGEMENT CRSP ADMINISTRATION

The Management Entity and office of the Management Entity is at North Carolina State University. With the merger now in place, the Soil Management CRSP now includes Cornell University, University of Hawaii, North Carolina State University, Texas A&M University, United States Department of Agriculture's Agricultural Research Service, Economic Research Service and the Soil Conservation Service.

This merger has brought on board two (2) new Board members, Dr. Jan van Schilfgaarde of USDA/ARS and Dr. Robert R. Shaw of USDA/SCS, and two (2) new Technical Committee members, Dr. John C. Day of USDA/ERS and Dr. Hari Eswaran of USDA/SCS. With the expected merger of NifTAL in 1994, Dr. Paul Singleton is also serving as a Technical Committee member.

A. External Evaluation Panel

The External Evaluation Panel is composed of three scientists with distinguished careers: Dr. Parker Pratt, Professor Emeritus, University of California--Riverside; Dr. William E. Larson, University of Minnesota; and Dr. Clarence C. Gray III, Professor Emeritus, Virginia Tech. The EEP has served in guidance during the program merger and developing some long range concepts in support to the Board and the Director of the Office of the Management Entity.

B. CRSP Special Planning 1990-91

1. Merger of TropSoils, TSMM and SMSS

The purposed program merger of the activities in soil and water management in the AID/R&D Bureau was administratively completed in this past year. A new grant was initiated on July 28, 1991, to carry through September 24, 1994, was implemented with new subgrants to the four (4) universities and cooperative agreements with USDA/ARS, USDA/ERS and USDA/OICD. Some of the program activities are in the phase of joint planning and merger at this time.

2. Enhancement Funds

Twenty (20) percent enhancement funds were received and new work plans and budgets were prepared base on project activity approval by the Board of Directors. These funds

will strengthen some new initiatives and cross-cutting activities.

C. 1990-91 Budget Allocations

The 1990-91 allocations, including enhancement allocations, from April 17, 1991--September 24, 1991, are presented in Table 1. Because the merger of only the TSMM funded activities were included in the new grant period from July 28, 1991--September 24, 1991, the numbers are not included in this table. The lag time between new start-up date, receiving the core grant and finalizing the subagreements did not permit any allocations until the 1991-92 fiscal year. Because of the close of the previous TropSoils core grant, these allocations do not reflect true expenditures.

D. Ten-Year Disbursement Summary

The ten-year summary of disbursement of CRSP are presented in Table 2. To bring the Soil Management CRSP in line with other CRSPs, the tenth year accountability split out actual costs for services of the BOD, TC and EEP and special funds used to support activities in the participating institutions. This calculates out to 84 percent disbursement to the activities of the four participating institutions and 8.7 percent for the Director of the Office of the Management Entity. With travel restrictions during part of the year, very prudent purchase of airline travel and other price control management measures, kept costs low with respect to the total core budget. Funds held in reserve and saved within the ME office allocation were reallocated to support research and outreach activities. The ten years of disbursements are presented in Table 2.

E. Office of the Management Entity

Some updating in the Office of the ME were completed in 1990-91. The CGNET electronic mail system was put into operation BINET is also in place and should soon be operational. A new Xerox was needed and purchased.

With the employment of Mr. Tim McBride, as the coordinator of the Communications project, this position is now housed with the ME. This has greatly improved his capability to interact with the institutions in the CRSP.

F. Miscellaneous

Upon AID/R&D request, the Soil Management CRSP summarized reported buy-ins and additional fundings for the period 1989-1992 (estimated). This is presented in Table 4. This reports about $913,800 extramural funding was gained during the 1990-92 fiscal year. These numbers do not reflect the 25 percent matching funds as mandated in the core grant.

Table 1
SOIL MANAGEMENT CRSP - YEAR 10
1990-91 BUDGET ALLOCATIONS

PROJECT NUMBER	TITLE	INITIAL ALLOCATION	MID-YEAR ENHANCEMENTS	TOTAL ALLOCATIONS
I.	Research Site Operations			
UHTS-01	Sitiung, Indonesia	$ 160,000	$ 0	$ 160,000
NCTS-01	Yurimaguas, Peru	160,000	0	160,000
TXTS-01	Niamey, Niger	160,000	0	160,000
		$ 480,000	$ 0	$ 480,000
II.	Campus Backstopping			
UHTS-02	Hawaii-Indonesia	$ 39,000	$ 0	$ 39,000
NCTS-02	North Carolina State-Peru	60,000	0	60,000
TXTS-02	Texas A&M-Niger	76,424	0	76,424
		$ 175,424	$ 0	$ 175,424
III.	Natural Resource Management			
CU-04	Soil Degradation	$ 108,387	$ 0	$ 108,387
NCSU-01	Comparative Agronomics	65,000	7,600	72,600
NCSU-02	Soil Characterization	35,000	10,800	45,800
TAMU-01	Soil Degradation	55,155	0	55,155
TAMU-04	Land Resource Characterization	27,350	0	27,350
TAMU-05	Water Management	0	45,000	45,000
CU-05	Watershed Honduras	0	8,244	8,244
TAMU-07	Watershed Honduras	0	6,412	6,412
NCSU-06	Collaboration with IRRI	0	11,500	11,500
		$ 290,892	$ 89,556	$ 380,448
IV.	Sustainable Agriculture Production			
CU-01	Maize Rainfall	$ 61,845	$ 0	$ 61,845
CU-02	Nitrogen Pathways	59,273	0	59,273
CU-03	Green Manures	59,273	6,412	65,685
UH-03	Detoxifying Aluminum	17,310	7,328	24,638
UH-07	Base Cation Dynamics	17,205	0	17,205
NCSU-03	Sustainable Soil Management	50,000	0	50,000
NCSU-04	Agroforestry Systems	50,000	7,600	57,600
TAMU-02a	Soil and Water Management	27,196	0	27,196
TAMU-02b	Soil and Water Conservation	27,196	0	27,196
TAMU-03	Soil Fertilizer Management	53,539	0	53,539
CU-06	Cameroon Initiative	0	12,366	12,366
UH-02	Collaboration with IRRI	0	7,328	7,328
UH-05	Collaboration with IITA	0	7,786	7,786
NCSU-07	NCSU-TSBY Collaboration	0	6,400	6,400

Table 1 (continued)

PROJECT NUMBER	TITLE	INITIAL ALLOCATION	MID-YEAR ENHANCEMENTS	TOTAL ALLOCATIONS
TAMU-08	Cameroon Initiative	0	9,160	9,160
TAMU-09	InterCRSP-Peanut/INTSORMIL	0	4,122	4,122
TAMU-11	Collaborate with ICRISAT	0	4,122	4,122
		$ 422,837	$ 72,624	$ 495,461
V.	Outreach			
PDSS-01	P Decision Support System	$ 61,350	$ 7,328	$ 68,678
UH-04	Maize/Legume Systems	24,770	7,328	32,098
NCSU-05	Humid Tropics Network	60,000	5,130	65,130
TAMU-06	INTSORMIL InterCRSP	5,160	0	5,160
TAMU-10	SAT Outreach	36,336	0	36,336
COM-01	TropSoils Communications	150,000	9,160	159,160
PDSS-02	Phosphorus DSS Workshop	0	18,320	18,320
		$ 337,616	$ 47,266	$ 384,882
VI.	CRSP Operations			
	BOD, Technical Committee, EEP	$ 58,400	$ 0	$ 58,400
	Special Watershed Publication	0	0	35,000
	Special Cameroon Project Support	0	0	6,000
	Office of the Management Entity	334,831	8,152	301,983
		$ 393,231	$ 8,152	$ 401,383
	TOTALS	$2,100,000	$ 217,598	$2,317,598

Table 2

Soil Management CRSP Disbursements 1981-1991

	YEAR OF CRSP										
	1 81-82	2 82-83	3 83-84	4 84-85	5 85-86	6 86-87	7 87-88	8 88-89	9 89-90	10 90-91	Total
	($1,000)										
Cornell	-----	225	-----	336	395	443	352	319	308	375	2,753
Hawaii	-----	660	-----	716	675	454	353	303	322	420	3,903
N. C. State	-----	2,531	-----	1,028	1,090	651	522	514	481	571	7,388
Texas A&M	-----	1,152	-----	729	752	543	431	476	481	589	5,153
ME	-----	487	-----	417	480	387	306	292	222	202	2,793
Communications	-----	-----	-----	-----	-----	55	94	150	150	132	581
Cont/Plan/Sp. Requests/Reserve	-----	-----	-----	-----	-----	46	43	31	147	-----	267
BOD	-----	-----	-----	-----	-----	-----	-----	-----	9	9	18
TC	-----	-----	-----	-----	-----	-----	-----	-----	10	10	20
EEP	-----	-----	-----	-----	-----	-----	-----	-----	10	10	20
	-----	5,055	-----	3,226	3,392	2,579	2,101	2,085	2,140	2,318	22,896

TABLE 3

MANAGEMENT ENTITY 1990-91 EXPENDITURES
September 25, 1990--September 24, 1991

I.	SALARIES AND BENEFITS		
	A. Salaries		
	Director	$73,150	
	Adm. Assistant	26,016	
			$ 99,166
	B. Benefits (23.9%)		
	Director	$11,635	
	Adm. Assistant	6,242	
	Staff Benefits	460	
			$ 18,337
II.	OPERATIONS		
	A. Telephone and Fax	$ 3,143	
	B. Postage--Mailings	2,575	
	C. Services/Rents/Repairs	6,412	
	D. Supplies	5,002	
	E. Equipment	10,886	
	F. Miscellaneous	30	
			$ 66,503
III.	TRAVEL AND RELATED EXPENSES		
	A. Director, Management Entity	$41,726	
	B. Board of Directors	8,456	
	C. Technical Committee	10,492	
	D. External Evaluation Panel	5,629	
	E. Related Travel Expenses	200	
			$ 66,503
IV.	INDIRECT COSTS		$ 83,299
	TOTAL		$295,353

Table 4

SOIL MANAGEMENT CRSP
BUY-INS AND ADDITIONAL FUNDINGS

University/Project	Fiscal Year 1989	1990	1991	1992(Est)
			$	
Texas A&M University				
USAID/Niger Watershed Project	160,000	-	250,000	250,000
USAID/Niger Graduate Training	22,000	11,000	-	-
USAID/Honduras Local Funds	-	-	4,000	-
USAID/Cameroon Graduate Training	12,500	12,500	12,500	-
USDA/ARS, Bushland, TX, Graduate Training	-	-	5,000	5,000
USDA/ARS, Temple, TX, Vertisol Research	-	5,500	5,500	-
SMSS/USDA-SCS Research Grant	-	-	9,500	9,500
Rockefeller Foundation Graduate Training	-	24,000	-	-
Peanut CRSP - Collaborative Research	7,100	-	-	7,100
INTSORMIL CRSP - Collaborative Research	-	5,000	5,000	5,000
University of Hawaii				
USAID/Indonesia BOA - Outreach	184,500	-	-	-
CSAR, Indonesia	4,800	4,800	4,800	-
SARIF, Indonesia	2,400	2,400	2,400	-
UH-College of Trop. Agr. & Human Res.	12,500	12,500	12,500	-
Andalas University, Ind. Grad. Students	15,000	15,000	-	-
Other Graduate Students (Many Donors)	105,000	105,000	105,000	105,000
North Carolina State University				
National Science Foundation	75,000	75,000	150,000	150,000
Rockefeller Foundation	-	20,000	20,000	-
IDRC (Canada)	8,000	8,000	8,000	-
USDA	30,000	-	-	-
USAID/S&T	40,000	60,000	60,000	-
Texasgulf, Inc.	-	-	25,000	25,000
Potash and Phosphate Institute	5,000	5,000	5,000	5,000
USAID Mission--LAC	36,000	36,000	36,000	36,000
USAID Mission--Africa	36,000	36,000	36,000	36,000
CSAR, Indonesia (Graduate Assist.)	-	-	9,600	9,600
IRRI	-	-	8,000	8,000
Cornell University	NOTHING REPORTED			
Management Entity Office				
Communications Project--CEWD	-	-	8,000	-
ME Director - AID/S&T/Economics	-	42,000	100,000	58,000
ME Director - USDA/FERRO - India	-	-	32,000	32,000
TOTAL	755,800	479,700	913,800	741,200

VI. PROGRAM SUMMARIES

A. Natural Resource Management

1. Comparative agronomic, ecological, and socio-economic analysis of humid tropical production systems.

Constraints addressed: Land-clearing pressure, inadequate resource information, production-demand pressure.

Project leaders: C. A. Palm, NCSU
J. C. Alegre, NCSU

Research collaborators by institution:

C. B. Davey, NCSU
A. G. Wollum, NCSU
P. O. Ruiz, NCSU
A. Salazar, NCSU
L. Arevalo, INIAA
L. T. Szott, CATIE, IDRC
G. Melendez, INIAA
B. Pashanasi, INIAA
P. Lavelle, Ecole Normale Superieur
E. T. Elliott, Colorado State University
W. J. Parton, Colorado State University

PROJECT PROGRESS REPORT

During the sixth year of the experiment, 3.7 t/ha of corn grain was harvested in the 13th crop for high-input treatment following a five-month fallow of mucuna. The fallows help combat weeds during the wettest months when tractors cannot be used. The low-input treatment was in fallow for most of 1991, following a rice (1.7 t/ha) and cowpea (1 t/ha) rotation in 1990. Year-long fallows in low-input systems are useful for weed control and for maintaining soil fertility. Fruit production has continued and increased in the two agroforestry systems. These two systems are a peach palm plantation with *Centrosema macrocarpum* ground cover and a multistrata tree production system with peach palm and tornillo, a valuable timber species, as the upper story trees: *Inga edulis*, a leguminous tree, as a middle story species; and *Eugenia stipitata*, araza, as an understory shrub. The peach palm plantation received 90 kg N/ha during the two initial years of cropping with rice and cowpea. The multistrata system has never been fertilized. Peach palm fruit production was 12 and 7

t/ha in the peach palm and multistrata systems, respectively. The lower yields in the multistrata system reflect the exclusion of inputs, and competition among tree species. Fruit production was variable and low in araza. This was primarily due to the intense shading caused by the *Inga edulis* trees. Because of strong competition for nutrients and light by the fast growing *Inga edulis* it was decided to prune or thin these trees and plant other understory trees. Monitoring of the soil chemical and physical properties and nutrient cycling has continued as described in last year's report.

2. Processes of soil degradation and rejuvenation under different land use systems.

   Constraints addressed: Landscape restrictions, inadequate resource information.

   Project leaders: L. P. Wilding, TAMU/TAES
   A. S. R. Juo, TAMU/TAES

   Research collaborators by institution:

   J. Heil, TAMU/TAES
   C. Coulombe, TAMU/TAES
   A. Manu, TAMU/TAES
   M. Ouattara, INRAN, Niger
   J. Takow, IRA, Cameroon
   Z. Kouyate, IER, Mali
   K. McInnes, TAMU/TAES
   R. Knight, TAMU/TAES
   F. W. Chichester, TAMU/TAES
   K. N. Potter, TAMU/TAES

PROJECT PROGRESS REPORT

The overall goal of this project is the characterization of land degradation and rejuvenation processes with regard to soil structure, water movement and nutrient cycling under various land management systems.

Field work for a study addressing the characterization of surface sealing processes in Sahelian soils was completed in Niger (Hamdallaye) and Mali (Cinzana Research Station). Infiltration and penetrometer measurements were obtained from selected sampling sites throughout the two locations. Intact block and bulk samples were taken and are presently being analyzed.

Research addressing the structural changes in a Vertisol was initiated in 1990. The research consists of a sub-study in Temple, Texas, and a major study to be conducted in Cameroon. The goal of the sub-study is to compare the effects of no-tillage cultivation by analyzing soil physical properties of sites with known treatment durations. Field work under this study was conducted in 1991 and consisted of impregnation of samples with resin. Presently, the samples are being cut and prepare for image analysis. The final proposal for the study to be conducted in Cameroon is presently being prepared.

3. Integrated management of small agricultural watersheds.

Constraints addressed: Landscape restrictions, inadequate resource information, climatic variability, production-demand pressure.

Project leaders:
A. Manu, TAMU/TAES, Niger
A. S. R. Juo, TAMU/TAES
S. Maranz, TAMU/TAES, Niger
M. Hassan, INRAN, Niger

Research collaborators by institution:

M. Ouattara, INRAN, Niger
M. Gandah, INRAN, Niger
M. Saadou, University of Niamey, Niger
F. Beidari, INRAN, Niger
A. Berrada, NAAR, Niger
S. Geiger, TAMU/TAES, Niger
E. Taylor-Powell, Consultant, Niamey, Niger
T. Thurow, TAMU/TAES
R. Puentes, TAMU/TAES
L. P. Wilding, TAMU/TAES
L. R. Hossner, TAMU/TAES
C. Wendt, TAMU/TAES
M. Issaka, INRAN, Niger
R. J. van der Beldt, ICRISAT, Niger
F. Smeins, TAMU/TAES
A. Bationo, IFDC/ICRISAT
C. K. Reddy, NAAR/INRAN
J. Lowenberg Deboerr, NAAR/INRAN
Djibo Hadiza, Niger
M. Ibro, INRAN, Niger

PROJECT PROGRESS REPORT

The overall goal of this project is to develop sustainable agricultural watershed management technologies suitable for the physical and

socioeconomic conditions of SAT Africa. Partial support of this project is received through a direct contract with USAID/Niger. This project consists of a number of studies for which activities and accomplishments are briefly outlined below.

Diguettes were constructed on the Hamdallaye plateau prior to the 1990 rainy season to investigate whether natural regeneration of vegetation would occur if favorable microsites for seedling establishment were provided. At the end of the 1991 rainy season, biomass production was assessed. Dry matter production in the diguettes constructed in the bare corridors was not significantly different from those in the broken tiger-bush stripes. Almost all of this vegetation was annual and, therefore, produced in one rainy season rather than two. The results from this study suggest that natural revegetation of perennials on the laterite plateaus is ineffective if the plants are left unprotected from grazing.

Acacia senegal plantations may be viable land-use for both the plateau and the valley. A major constraint to the adoption of *A. senegal* by farmers in Niger is the five-to-ten year establishment period required for the trees to reach maturity and produce gum arabic. The time to reach maturity may be significantly reduced through the use of the practice of air-layering. Approximately 100 air-layers were completed using cuttings from three mature, gum producing *A. senegal* trees. Further research is presently being planned to assess the agro-sylvicultural use of *A. senegal*.

Following the 1991 rainy season, three 35x35 m exclosures were put up to protect first-year bush fallows. These protected fallows will be used to compare soil fertility rejuvenation relative to the traditional fallow system in which livestock are permitted to graze the vegetation. Biomass production was sampled in the three first-year fallows and, also, in two second-year protected fallows. Biomass production was similar for both first-and-second-year fields. Results from this study emphasize that within this annual grass savanna ecosystem, primary productivity during the short rainy season is high. Fallow recovery in subsequent years will be assessed by measuring nutrient inputs in the form of dust, vegetation persistence, soil analysis and millet yields.

A study set up to compare the traditional cowpea-millet intercrop system with improved intercrop management

packages recommended by INRAN, TropSoils SAT and ICRISAT was initiated in 1991. Yields of both millet and sorghum were relatively higher on soils occurring on the upper to mid-slope positions within the watershed compared to the degraded, highly leached soils on the valley walls. The most important cultural practice influencing yield of both crops was the timeliness of the first weeding which accounted for almost 80 percent of yield variation. The other principal yield determinant was plant density. Farmer acceptability and socioeconomic impact of the recommended package is being evaluated based on formal and informal interviews with farmers, chiefs and elders of the villages.

A project initiated to assess and document the roles women play in natural resources management in the IMAW project site at Hamdallaye. Women's rights in the land tenure system, their access to resources such as trees, fodder and water are currently being evaluated.

Phosphorus deficiency for crop growth is very prevalent in the semi-arid tropics. Sustainable crop production thus calls for the application of both organic and inorganic forms of P. Soil tests are, therefore, necessary to assess the P status and to determine fertilizer recommendations that will maximize efficiency of fertilizer use. The major objective of this study was to assess the suitability of four P extraction procedures on soils of wester Niger. The effect of different soil-to-solution ratios on amounts of extractable P was investigated as part of this study. Through laboratory and greenhouse work, it was established that Bray P-1, with soil-to-solution ration of 1:7 gives the best index of P availability in the millet-producing soils of western Niger.

4. Land resources characterization and evaluation in the SAT.

Constraints addressed: Inadequate resource information, landscape restrictions.

Project leaders: L. R. Wilding, TAMU/TAES
A. S. R. Juo, TAMU/TAES

Research collaborators by institution:

L. R. Drees, TAMU/TAES
A. Manu, TAMU/TAES, Niger
M. Ouattara, INRAN, Niger
M. Salou, INRAN, Niger

R. Puentes, TAMU/TAES
P. Sankara, Univ. of Ouagadougou, Burkina Faso
O. Smith, TAMU/TAES
C. T. Hallmark, TAMU/TAES

PROJECT PROGRESS REPORT

The overall goal of this project is to characterize, quantify and evaluate land resources as baseline data for resource management research and technology transfer. Several studies of research are being conducted under this research project, one which focuses on the role of dust in the nutrient renewal and loss processes and the remaining which relate to the evaluation of soil conditions and the identification of soil-based crop production constraints.

Dust collection and analysis for 1991 obtained at the ICRISAT Sahelian Center was added to the data base which was initiated in 1985. There were no unique findings during the 1991 collection period. Continuation of this study is anticipated since it is one of the few dust monitoring projects which also seeks to examine the nutrient status of atmospheric dust as a possible nutrient renewal vector.

The Peanut CRSP and TropSoils CRSP in collaboration with the University of Ouagadougou, Burkina Faso, are combining their expertise to (1) evaluate soil conditions, (2) determine field plot uniformity and (3) identify soil-based crop production constraints at major Peanut CRSP breeding/selection trials in Burkina Faso. During the past year, most of the routine physical, chemical and mineralogical properties have been analyzed for 30 soil samples from three sites.

Results of this study indicate the general soil characteristics in regions of peanut production are (1) deep, well-drained soils, (2) sand surface horizons and loamy to clayey subsoils, (3) medium to strongly acid, (4) low activity kaolinite/iron oxide clays, (5) low to high mineral reserves and (5) negligible to high exchangeable Al.

In general, peanut research plot sites were uniform and representative of major peanut production regions of Burkina Faso. Soil variability was due primarily to (1) soil drainage, (2) horizon depth and thickness, (3) depth to bedrock and (4) depth to root restrictive plinthite.

The soil-based constraints at research sites in Burkina Faso included (1) degraded, weakly-structured surface soils, (2) soil crusting and sealing, (3) high soil erosivity to wind and/or water, (4) low organic matter content for nutrient and water retention, (5) high P-fixation and/or low availability and (6) soil infertility.

5. Processes of soil degradation and rejuvenation under different land use systems.

Constraints addressed: Inefficient use of water resources and high erosion rates.

Project leader: D. Keith Cassel, NCSU

Research collaborators by institution:

Dennis Garrity, IRRI, Philippines
Fahmuddin Agus, CSAR, Indonesia
Philippe Baveye, CU
Murray McBride, CU
Larry Wilding, TAMU

PROJECT PROGRESS REPORT

The research site was selected in May 1991 when Fahmuddin Agus, Roger Hanson, and Keith Cassel traveled to the Philippines. The site is near Claveria, Mindanao, the Philippines. Dennis Garrity, who serves as co-advisor to Fahmuddin Agus on the research project, offered alternative sites with established hedgerows on steeply sloping land. The hedgerow vegetation is *Glyrcidia sepium*, *Pennisetum purporem*, or a combination of these two species. The hedgerows, planted at four to five meter spacings and, usually on the contour, help slow runoff and decrease soil erosion. Several of the sites were already instrumented with runoff and sediment collecting devices. Two of the instrumented sites, plus one where the sediment and runoff collector will have to be constructed, were chosen.

The first crops (corn and upland rice) were planted in late May. Each plot was instrumented with tensiometers to assess the depth of soil-water recharge as rainfall infiltrates the sloping land. Tensiometers also allowed determination of the crop rooting depths. Potassium bromide was broadcast on the soil surface to serve as a tracer to further define the path of soil-water recharge and to assess the potential rates of nutrient leaching. Plans to use the neutron meter to

monitor soil water content on a daily to weekly basis were delayed due to the slow process of obtaining permission to use the radionuclide source at this field site. Samplers to collect free drainage water flowing below selected depths will also be installed in these plots.

Due to the rush to get a site selected and the first crop planted, the detailed site characterization data must still be collected.

6. Soil characterization and interpretation of natural resources management in the humid tropics.

Constraints addressed: Inadequate soil resource information, landscape restrictions.

Project leader: S. W. Buol

Research collaborators by institution:

S. W. Buol, NCSU
H. Eswaran, USDA-SCS
K. Matungulu, NCSU
T. F. Muamba, NCSU
S. E. Monteith, NCSU

PROJECT PROGRESS REPORT

Soil profiles at national agricultural experiment stations in seven agroecological zones of Zaire were sampled and chemical, physical and mineralogical analyses conducted. Ultisols, Andisols, Oxisols, Entisols, Alfisols and Inceptisols have been identified. Although both ustic and udic soil moisture regimes were sampled, most soil conditions are more related to parent material than climate. Highest contents of exchangeable bases are present in the Andisols of Eastern Zaire but they also have very high phosphate retention properties. Soils found in the Kalahari sands have low contents of most nutrients and appear deficient in Zn, Cu and Mn.

Preliminary sampling of soils of six contrasting geomorphic sites in Madagascar have been completed and laboratory results indicate slight soil chemical differences. All soils are highly aluminum saturated in the surface, 75 to 90 percent, and have very low contents of bases and phosphate in the subsoil. Soil mapping of the Ranomafana area is in progress.

Detailed soil maps have been prepared at two experiment stations in the Chapare region of Bolivia and several soil profiles have been sampled for laboratory studies. These samples include soil profiles on the research stations and a few from surrounding areas that will be mapped next year.

Soil organic matter incubation studies are nearly complete. Considerable differences have been noted in the rate and resulting soil conditions after the two year incubation period. These appear related to initial soil mineralogy and are identifiable by taxonomic classification of the soil but final analysis of the data is not yet complete.

7. Primary site operations, Sitiung, Indonesia.

Constraints addressed: Inadequate resource information, climatic variability, soil acidity, nutrient deficiencies and losses, water stress, knowledge gaps, lack of skills and research capability.

Project leaders: Lalit Arya, UH
Goro Uehara, UH
Gordon Tsuji, UH

Research collaborators by institution:

Agus Sofyan, CSAR
I. P. G. Widjaja-Adhi, CSAR
Zulkifli Zaini, Sukarami Research Institute

PROJECT PROGRESS REPORT

Primary site operations included: (1) field research, (2) maintenance of buildings and grounds, (3) procurement and maintenance of supplies and services including motor vehicles, motorbikes, generators, computers, office facilities, and laboratory and field equipment, (4) maintenance and supervision of local staff, (5) accounting and reporting, (6) liaison activities which included receiving visitors and facilitating their stay and work in Sitiung, arranging meetings, and facilitating interactions between USAID, CSAR, and the University of Hawaii, and (7) collaborative work with government officials, farmers, and local research institutions.

Research activities were primarily focused on: (1) observations of the residual effects of surface and deep-applied lime, (2) organic material management, (3) management of an alley-cropping system, (4) soil

structural effects on water movement and nutrient transport, and (5) potassium dynamics and management in highly-weathered Ultisols and Oxisols.

Budget constraints affected research and other activities. Some of the CSAR staff were moved to other locations in Indonesia and the number of locally hired staff was reduced to a minimum. Finally, a decision was made to recall the two University of Hawaii staff stationed in Sitiung and hand over management of the site to the Center for Soil and Agroclimate Research. All equipment and project property were transferred to the Government of Indonesia. The handing over of the site was officially completed on June 30, 1991.

8. Base cation dynamics in low base status tropical soils.

Constraints addressed: Low levels of Ca, Mg, and K. High annual rainfall and low cation retention capacity create a high potential for large losses of applied base cations.

Project leaders: R. S. Yost, UH
T. S. Dierolf, UH
L. M. Arya, UH

Research collaborators by institution:

I. P. G. Widjaja-Adhi, CSAR, Indonesia
Agus Sofyan, CSAR, Indonesia

PROJECT PROGRESS REPORT

Macropore flow has been identified as an important process in the highly-weathered Ultisols of Sitiung. We have tentatively related the effect of macropore flow to the (1) high potential for leaching losses to surface applied chemicals, and (2) the difficulty of building up subsoil fertility because most of the soil matrix is bypassed by incoming water.

All trials have been completed including: (1) a two-year, six crop trial evaluating the effect of potassium fertilizer and crop residue management on the soil K pool; (2) water flow trials to characterize the nature of water movement (infiltration and drainage); (3) K diffusion trial--to evaluate the effect of soil-KCl fertilizer equilibration time (0 to 27 days) on the retention of K following irrigation with 92 mm of water; and (4) rice straw ash trial--to evaluate the effect of incorporation versus surface application of

rice straw ash on cation retention following irrigation with 40 mm of water.

Many of the soil and plant samples are still in the process of being analyzed thus results and conclusion are forthcoming.

9. Integrated management of crops under variable rainfall conditions in the tropics.

Constraints addressed: Climate variability, water stress, site-specifity of management practices.

Project leaders: Susan J. Riha, CU
Beverly McIntyre, CU
David Flower, ICRISAT, Kano, Nigeria
Peter Crauford, IITA, Kano, Nigeria

PROJECT PROGRESS REPORT

Field experiments conducted in Kano, Nigeria, in collaboration with ICRISAT and IITA have been analyzed. The general design of these experiments was to grow the cereal crop under irrigated conditions to the post-panicle initiation stage and to then stop irrigation on half the plots. At this stage, daily measurements of soil water content at several depths were taken, as well as above-ground plant measurements. A major goal of this project has been to assess the strengths and limitations of biophysical crop models when applied to cereal crops grown under rainfed conditions in the tropics. We have examined models that are primarily concerned with the interception of radiation in conjunction with the expansion of the canopy and models that examine water uptake by roots in relation to atmospheric demand, root distribution and soil properties.

A potential driven water uptake model that assumed a static, exponentially decreasing root density at the beginning of the experimental period (post-panicle initiation) was compared with a resource capture model that assumed a moving root water extraction front and an exponential decrease in water uptake with time in soil which roots had penetrated. We found that the potential driven water uptake model, using values for root density and stomatal conductance-leaf water potential functions developed for maize in the U.S., very closely described both the pattern of soil water uptake, actual transpiration, leaf water potential and stomatal conductance. This model predicted, and the field experiment verified, that leaf water potentials

became more negative within a week after suspending irrigation. However, there was no effect on stem elongation for the next 12 days, except in one experiment. The marked decrease in stem elongation in this case was attributed to high soil surface temperatures, rather than to drought stress.

10. Process of soil degradation/rejuvenation under different land use systems.

Constraints addressed: Soil structure, crusting.

Project leaders: Philippe Baveye, CU
Murray McBride, CU
Host-country scientists to be named

Research collaborators by institution:

Charles Bielders, CU
Kirsten Verburg, CU
Eugenio Marcano-Martinez, CU
Worou, INS, Lome, Togo
Ricardo Radulovich, CATIE, Costa Rica

PROJECT PROGRESS REPORT

Eugenio Marcano-Martinez' research focuses on the chemical aspects of aggregate stability Ultisols and Alfisols of Costa Rica, using soils from Puerto Rico and Brazil for comparison purposes. In the past year, several soils with oxic characteristics have been sampled and prepared for analysis. Mineralogical studies were done by powder X-ray diffraction techniques. The predominant minerals in the clay fraction of these soils were found to be kaolinite, goethite, gibbsite, and hematite. Preliminary observations of some aggregates and dispersed clays under a scanning electron microscope revealed uniform coatings of the aggregates by very fine particles (possibly Fe or Al oxides).

Charles Bielders' work is related to the processes leading to the formation of surface crusts in oxisols of southern Togo, and addresses the effect of the crusts on infiltration and water availability. Following a first trip to Togo in July/August 1990, it was decided that southern Togo offered a number of favorable conditions for research and it was, therefore, chosen as a site for the present Ph.D. research. The study will combine fundamental laboratory research on the processes of crust formation together with assessments of crusting and the effects

of different tillage practices in the field. This topic was chosen on the basis of results of previous studies that had revealed the potential importance of crust formation in the area.

In the spring of 1991, a number of laboratory and field methods were developed in Ithaca for later use in Togo. During a second trip to Togo in September/October 1991, practical arrangements were made to facilitate future work and some preliminary soil physical characterization measurements were performed. A specific site was chosen in the most intensively cultivated, and most degraded, area of southern Togo where field experiments on soil crusting will be conducted during the spring of 1992. Charles Bielders has passed his A examination in May 1991; he is now working full time on research.

Kirsten Verburg, who joined the project in August 1990, went through two semesters of coursework. She has been familiarizing herself in the lab with various methods used in the study of ion exchange and variable charge characteristics of soils.

B. Sustainable Agriculture Production

1. Cereal/legume/rhizobium systems: interspecific interactions, nitrogen fixation, and yield responses on acid soils.

Constraints addressed: Production-demand pressure, soil acidity, nutrient deficiencies and losses, water stress, site-specificity of management practices, gap between new information and useable knowledge.

Project leaders: R. Caldwell, UH
P. Singleton, UH

Research collaborators by institution:

Basil Acock, USDA/ARS, Beltsville, Maryland
Abdul Ghani, SARIFC, Indonesia
Robert Grant, University of Alberta
C. Allan Jones, TAES
Jim Jones, University of Florida
Susan Miyasaka, UH
Tasman Naim, SARIFC, Indonesia
Agus Sofyan, CSAR, Indonesia
I. P. G. Widjaja-Adhi, CSAR, Indonesia

PROJECT PROGRESS REPORT

While maize is an important staple in many parts of the developing world, other cereals also play important roles in multiple cropping systems. In order to broaden the geographical applicability of the project, research objectives were modified to include systems with rice, wheat, sorghum, and millet, as well as maize.

CropSys, a computer model developed at the University of Hawaii, was modified to simulate intercrops and sequential crops of the five cereal species with a legume. The model is designed to simulate (1) interspecific competition for light, water, and soil nitrogen, (2) residual effects of crops on water and nitrogen relations in crop sequences, and (3) within-season and between-season transfers of biologically fixed nitrogen. This work was the basis for an invitation to the International Symposium on Systems Approaches for Agricultural Development, to be held December 2-6, 1991, at the Asian Institute of Technology, Bangkok, Thailand.

The modified version of CropSys (v. 2.0) is being prepared for release as a product of the TropSoils program.

2. Detoxifying aluminum and reducing P-fixation in variable change soils with organic amendments.

Constraint addressed: Soil acidity.

Project leader: N. V. Hue, UH

Research collaborators by institutions:

Agus Soyfan, CSAR, Indonesia
L. Arya, UH
R. Yost, UH

PROJECT PROGRESS REPORT

The use of organic residues to correct Al phytotoxicity and Ca deficiency was evaluated on to acid soils in a greenhouse experiment. Cowpea (*Vigna unguiculata*) and pineapple (*Ananas comosus*) residues were incorporated into an Ultisol (pH 4.6) and a highly leached Andisol (pH 4.5). The treatments included (1) unamended (control), (2) $Ca(OH)_2$, (3) MgO, (4) $CaSO_4$, (5) ground dry cowpea, (6) ashed cowpea at equivalent dry weight, (7) ground dry pineapple, (8) ashed pineapple at

equivalent dry weight. Evaluation of soil chemical data along with shoot dry weight of an acid sensitive indicator plant (*Desmodium intortum* cv. Greenleaf) indicated the following: (1) both cowpea and pineapple residues were effective in reducing Al toxicity, (2) cowpea was more effective than pineapple in correcting soil acidity, (3) fresh materials, especially cowpea outperformed their ashed counterparts, indicating significant organic-soil mineral interactions beyond supplying Ca, and (4) the positive effect of fresh cowpea residue on dry matter yield, in fact, surpassed that of $Ca(ON)_2$, suggesting benefits beyond detoxifying Al and providing Ca.

3. Honduran watershed management.

Constraints addressed: Accelerated soil erosion, soil acidity, water stress, diminishing land resource base.

Project leader: A. S. R. Juo, TAMU/TAES

Research collaborators by institution:

M. Thompson, TAMU/TAES
L. A. Welchez, SRN, LUPE Project, Honduras
D. Leonard, LUPE Project, USAID/Honduras
F. Gomez, Escuela Agricola Panamericana
D. H. Meckenstock, TAMU/TAES, INTSORMIL, Honduras
T. L. Thurow, TAMU/TAES
D. M. Vietor, TAMU/TAES
H. van Es, CU

PROJECT PROGRESS REPORT

The overall goal of this project is to provide soil management expertise in support of INTSORMIL programs and the LUPE project in Honduras. The principal activity under this research project during 1991 was the initiation of a study concerning the effect of land modifications on soil productivity and crop performance on steep lands in southern Honduras as described below.

A field study jointly supported by a TropSoils enhancement grant and the USAID Mission in Honduras was initiated to evaluate the effect of stonewall barriers on soil physical and chemical properties as well as crop productivity was conducted in southern Honduras during 1991. Paired sites (terraced and non-terraced) were selected on four fields. Site criteria required pairs to have similar slopes, soils, cropping history and management. Informal interviews with owners and families of each farm were conducted to provide basic

information for describing the socioeconomic setting. Crop productivity was evaluated by measurement of grain yield and total dry matter production. Physical and chemical soil factors (including texture, bulk density, percent coarse fragments, total N, organic C, effective CEC, available P and pH) are presently being analyzed.

4. TropSoils--INTSORMIL collaborative research.

Constraints addressed: Nutrient deficiencies and losses, soil acidity, water stress.

Project leaders: A. Onken, TAMU/TAES
A. S. R. Juo, TAMU/TAES

Research collaborators by institution:

L. R. Hossner, TAMU/TAES
Z. Kouyate, IER, Mali
O. Niangado, IER, Mali
M. Traore, IER, Mali
S. V. R. Shetty, ICRISAT, Niger
L. P. Wilding, TAMU/TAES
R. D. Lacewell, TAMU
D. T. Rosenow, TAMU/TAES
F. R. Miller, TAMU/TAES
L. Rooney, TAMU/TAES

PROJECT PROGRESS REPORT

The overall goal of this project is to provide soil management expertise in support of INTSORMIL plant breeding and agronomy programs in Mali. The principal activity under this research project during 1991 was the continuation of the nutrient deficiency and soil toxicity study at the Cinzana Research Station in Mali which is jointly funded by TropSoils and INTSORMIL.

The nutrient deficiency and toxicity study consists of assessing the growth of sorghum in response to differing soil amendments (manure, rock phosphate and lime). Data collected for the 1990 season exhibited large variabilities in stand establishment and crop growth within most experimental units. In addition, marked variabilities existed between replications.

Field data collected obtained during the 1991 season are not consistent with the trends of the previous year. Symptoms of early poor growth were displayed by no less than 86 percent of the planting hills of each of the soil amendment treatments. Variability in stand establishment was very pronounced within experimental

units (genotype). Additionally, leaf purpling of seedlings was observed only on *Babadia fara*, a genotype which has demonstrated excellent yield performance in previous evaluation studies. Major research components which have not yet been completed and analyzed may elucidate the interpretation of the data.

5. Soil fertility management for sustainable agriculture in the SAT.

Constraints addressed: Nutrient deficiencies and losses, soil acidity.

Project leaders: L. R. Hossner, TAMU/TAES
A. S. R. Juo, TAMU/TAES
C. W. Wendt, TAMU/TAES

Research collaborators by institution:

K. Grahammer, TAMU/TAES
Z. Kouyate, IER, Mali
A. Manu, TAMU/TAES, Niger
M. Ouattara, INRAN, Niger
M. Gandah, INRAN DRE, Niger
C. Zaongo, TAMU/TAES
J. Takow, IRA, Cameroon
M. Doubmia, IER, Mali
A. Onken, TAMU/TAES
R. W. Weaver, TAMU/TAES
T. W. Boutton, TAMU/TAES
W. Payne, ICRISAT, Niger

PROJECT PROGRESS REPORT

The overall goal of this project is to develop soil fertility management practices for sustainable food, fodder and fiber production under semi-arid conditions. Several studies of research are being conducted under this research project, one which focuses on residue decomposition and the remaining which relate to cropping and soil fertility management studies in Mali.

During the cropping season of 1991, field work for the residue decomposition study was conducted at N'Dounga, Niger. Addition of plant material to a sandy Alfisol cropped to millet was made in the form of millet and cowpea residues and as cowpea green manure. 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 N into the soil and subsequent plant uptake. Lab analyses are currently being conducted at Texas A&M

University. Preliminary results suggest an increase in millet straw and grain yields after application of millet or cowpea residues. Furthermore, intercropping millet with cowpeas subsequently incorporated as green manure did not affect millet grain yield.

An adjunct greenhouse experiment with the objective of quantifying N release during decomposition of cowpea residues was implemented in late 1990. Lab analyses of mineralized N in soil and plants were completed in the spring of 1991. Nitrogen released during decomposition of cowpeas grown to mid pod fill was more than double that released from cowpeas grown to flowering. It, therefore, is advantageous to turn under cowpeas at early pod fill instead of flowering when used for green manuring since N rapidly accumulates after flowering and the rate of N mineralization during decomposition in soil remains high.

In 1986, studies were initiated at the Cinzana Research Station (Mali) comparing the effect of various tillage treatments with and without P fertilizer on the yields of sorghum and cowpea in rotation. The final yield data on sorghum were obtained in 1989 and on cowpeas in 1990. In 1990, the unfertilized treatment produced insignificantly higher yields of cowpeas than fertilized treatments. Yields were not affected by tillage treatment in 1990. These data do not follow the trends of 1987, 1988 and 1989 in which yields were increased by both tillage and fertilization.

An infiltration study was also conducted at the Cinzana Research Station during this reporting period. The effect of tillage on infiltration from a rainfall simulator in a millet crop was conducted on a sandy loam and a clay loam soil. Both yield and infiltration data indicate that it is not worthwhile to employ the particular tillage treatments evaluated in the study for the cultivation of millet.

A cropping system management study at the Cinzana Research Station was initiated in 1990 with the objective to determine the effect of different cereal-legume rotations, tillage and crop residue management systems on soil physical and chemical properties and yields of sorghum and millet. A split plot design is being utilized to evaluate ridging and tied ridging treatments on sandy loam and clay loam soils. Legumes planted in the study are sesbania, dalicees, and cowpeas. The first yield data from the study have been obtained in 1991 and are currently being compiled and analyzed.

6. Soil and water management and conservation for sustainable agriculture in the SAT.

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

Project leaders: C. W. Wendt, TAMU/TAES
A. S. R. Juo, TAMU/TAES
L. R. Hossner, TAMU/TAES

Research collaborators by institution:

C. Zaongo, TAMU/TAES
A. Sow, IER, Mali
R. Schwartz, TAMU/TAES
A. Manu, TAMU/TAES, Niger
M. Ouattara, INRAN, Niger
M. Gandah, INRAN DRE, Niger
C. R. K. Prashar, PRAAN, Niger
R. J. Lascano, TAMU/TAES
Z. Kouyate, IER, Mali
B. A. Stewart, USDA/ARS, Bushland, Texas
P. W. Unger, USDA/ARS, Bushland, Texas
G. S. Brar, USDA/ARS, Bushland, Texas
D. W. Fryrear, USDA/ARS, Big Spring, Texas
B. L. Harris, TAMU/TAES
J. T. Bilbro, USDA/ARS, Big Spring, Texas

PROJECT PROGRESS REPORT

The overall goal of this project is to develop soil and water management practices for sustainable food, fodder, and fiber production under semi-arid conditions.

Collection of all field data was completed during the 1990 cropping season for a study investigating the interactive effects of water and nutrients on sorghum and cowpea growth. Additionally all laboratory soil physical, and hydraulic determinations pertaining to study objectives have been completed and the majority of laboratory analyses have been completed. Finally, a model for soil water balance has been partially calibrated for Sahelian conditions.

The first year of a field study investigating tillage and residue effects of dryland sorghum was also

completed during the 1991 cropping season in West Texas. Measurements of water balance (runoff, soil water content), soil strength, bulk density and rooting were taken at growth stages. Leaf area, leaf and canopy temperatures, dry matter and grain yields were also measured.

Collection of all wind tunnel and field data was completed during 1990-91 for a study investigating the modifications of air flow and surface shear stress resulting from sorghum wind barriers. Results from this study have permitted the development of methodology and equations which permit the design of more efficient wind barriers for the control of wind erosion.

7. Synchrony between soil nutrient availability and plant nutrient uptake.

Constraint addressed: Nutrient deficiencies and losses.

Project leaders: M. Wagger, NCSU
C. A. Palm, NCSU

Research collaborators by institution:

M. J. Swift, IITA, Nigeria
P. Woomer, TSBF, Kenya
K. Glasener, NCSU

PROJECT PROGRESS REPORT

This project just began in 1991. So far, a graduate student selected and research methodologies and design are being discussed. During the end of 1991 and the beginning of 1992, a research site will be selected in Bolivia, Kenya, Zambia, or Cameroon. Criteria for site selection will include the quality and accessibility of laboratory facilities, support staff, field sites, and other logistical considerations.

8. Sustainable soil management alternatives to slash and burn.

Constraints addressed: Soil acidity, nutrient deficiency and losses, soil physical limitations, erosion, water stress and weeds.

Project leader: J. C. Alegre, NCSU

Research collaborators by institution:

D. Lara, INIAA
W. Guillen, INIAA
M. Galvez, INIAA
J. Benavides, INIAA
T. J. Smyth, NCSU
J. Salinas, PDAR
C. Castilla, NCSU
P. Luna, NCSU

PROJECT PROGRESS REPORT

Low-input. The third cropping cycle, after one year of kudzu fallow, was similar to the second cropping cycle and sustained only two acceptable crops. Neither rice nor cowpea varieties responded to phosphorus fertilization. Fourteen different legumes are under evaluation for use as improved fallows. *Kudzu, Stylosanthes guianensis, Centrosema macrocarpum, Andropogon gayanus* and *Calopogonium caerelium* are performing well in terms of weed suppression and percentage of ground cover. Upland rice varieties ITA 235, IRAT 120, and one new variety from Colombia appear to have demonstrated improved resistance to acidity, blast and superior grain quality to the traditional germplasm. Three new cowpea lines from Africa showed high yield potential and tolerance to Al.

Mechanized continuous cultivation. Forty consecutive crops harvested during 18 year of continuous cultivation in a sandy loam Ultisol in Yurimaguas have maintained stable yields and soil properties have improved rather than deteriorated. There was a significant improvement in crop yields when a green manure (*Mucuna cochinchinensis*) was included in the annual rotation. Exclusion of in-row subsoiling from no till and minimum till systems reduced corn yields by 30 percent.

Legume-based pastures. A pasture with a pure stand (*Centrosema pubescens*) 438 continues to produce the highest and most consistent level of animal production over 11 years of grazing. The productivity and persistence of the associations of *Brachiaria humidicola* with *Desmodium ovalifolium* and *Adropogon guianensis* with *Centrosema macrocarpun* in terms of good animal gain weight have been demonstrated for 11 continuous years of grazing and are now being evaluated for milk production. Preliminary results are promising.

9. Agroforestry systems for acid soils of the humid tropics.

Constraints addressed: Soil acidity, nutrient depletion and losses, topographic limitation, water stress, weeds.

Project leader: C. B. Davey, NCSU

Research collaborators by institution:

Pedro A. Sanchez, NCSU
L. T. Szott, IDRC, CATIE
C. A. Palm, NCSU
A. Ricse, INIAA
J. M. Perez, INIAA
P. O. Ruiz, NCSU
A. A. Salazar, NCSU
B. Pashanasi, INIAA
E. C. M. Fernandes, NCSU
L. Arevalo, INIAA
M. Arcos, INIAA
D. Lara, INIAA

PROJECT PROGRESS REPORT

Research in the agroforestry program is concentrated on three technologies: (1) food tree systems, (2) alley cropping, and (3) managed fallows. Within each of these areas, emphasis is placed on germplasm selection, plant production, and nutrient, organic matter dynamics.

A silvopastoral system involving peach palm fruit production, legume ground cover and cattle was initiated. *Centrosema macrocapum* was planted in an established peach palm plantation and was found to be shade tolerant. During the initial phase of animal grazing, there was no negative affect on palms or soil properties. Research was initiated to study the impact of specific mycorrhizal fungi on P nutrition of peach palm grown for heart of palm production.

On-farm trials are conducted with 18 local farmers to produce peach palm seedlings for their own plantations. Among the leguminous trees used as hedgerows in alley cropping on Ultisols *Cassia reticulata* was the only species that provided sufficient P in its prunings to balance the P extracted in the grain of harvested crops. After 40 months of continuous cropping, the yields of rice and cowpea did not decline, available P increased and acidity declined. In sloping areas,

alley cropping in contours reduced soil losses and water run-off in comparison to a low-input cropping system by 28 fold and seven fold, respectively.

Roots of hedgerow trees responded to height and frequency of top pruning by sloughing nodules and mycorrhizal fine roots. Root and nodule regeneration paralleled foliage regrowth. Increasing severity of top pruning prolonged the root and nodule recovery period.

10. Utilization of green manures within cropping systems.

Constraint addressed: Nitrogen management.

Project leaders: D. R. Bouldin, CU
S. J. Riha, CU
W. S. Reid, CU
M. da Silva Cravo, CPAA, EMBRAPA

Research collaborators by institution:

Michael Cahn, CU
M. da Silva Cravo, CPAA

PROJECT PROGRESS REPORT

The general objective of this research was to study how urea and legume green manures in a corn production sequence may influence nutrient leaching in an Oxisol of the humid tropics, where subsoil acidity inhibits deep rooting.

A 1.3 year split-plot field experiment was conducted on a clayey Oxisol (Typic Acrudox), near Manaus, Brazil. Sub-plots were cropped (1) a legume green manure (*Canavalia ensiformes* or *Mucuna aterrima*) followed by maize, (2) maize receiving 300 kg/ha of urea-N, or (3) left bare-fallow with an application of 300 kg/ha or urea-N. Plots were periodically sampled to 1.2 m and soil water was monitored with tensiometers.

The experimental site received 4265 mm of precipitation during 1.3 years; approximately 60 to 90 percent of this rain percolated through the profile. Applied N and K leached from the plow layer and a significant portion of the nitrate leached beyond 1.2 m during the experimental period. Calcium and magnesium leached from the plow layer; some accumulated in the subsoil, and some was lost from the soil profile.

Acidity increased in the plow layer of unlimed plots during the experimental period. Plots cropped with canavalia were least acid and plots receiving urea were most acid. Soil acidification during the experimental period influenced crop yields.

11. Pathways of N flow in relation to crop utilization of applied N.

Constraint addressed: Nutrient supply and loss.

Project leaders: John M. Duxbury, CU
Jean Fruci, CU
F. Sanchez, Univ. of Costa Rica

PROJECT PROGRESS REPORT

Research in this period was conducted at two field sites: Caldwell Field, Cornell University, Ithaca, New York, and Hacienda La Pacifica, Canas, Guanacaste, Costa Rica. The field experiments in both areas focused on nitrogen cycling in the plant-soil system. The experiments at Cornell were done on a field with spring wheat and in a long-term pasture field. the experiments in Costa Rica were done on an unirrigated, unfertilized pasture system that is dominated by *Hyparrhenia rufa* (common name: Jaragua), a pasture grass commonly used throughout the tropics. In these experiments, ^{15}N was used as a tracer to examine both short term (24 hours) and long term (weeks to months) nitrogen distribution between the plant and soil system.

Samples of soil and plants will not be examined for total N and ^{15}N content.

C. Outreach

1. Outreach activities in the SAT.

Constraints addressed: Number and diversity of users, lack of local expertise and information, site-specificity of management practices, gap between new information and usable products.

Project leaders: A. Manu, TAMU/TAES, Niger
A. S. R. Juo, TAMU/TAES

Research collaborators by institution:

R. Puentes, TAMU/TAES
A. Bationo, IFDC, ICRISAT

R. Yost, UH
T. J. Smyth, NCSU
M. Ouattara, INRAN, Niger
M. Gandah, INRAN, Niger

PROJECT PROGRESS REPORT

The overall goal of this project is to synthesize and translate TropSoils research results from the semi-arid tropics into user-oriented products and disseminate these products to national users through networking, training and workshops.

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 within the region. One such collaborative effort has been established between IFDC/ICRISAT through the West African Fertilizer Management and Evaluation Network (WAFMEN). Two projects were executed through this collaborative effort, summaries of which are presented below.

A project addressing the effect of different long-term soil fertility management practices on selected chemical properties of a sand Sahelian soil was carried out at the ICRISAT Sahelian Center, Niger. In this long-term experiment, it has been established that the maintenance of adequate levels of organic matter in the sandy Sahelian soils is a prerequisite for sustainable agricultural production.

Another study was carried out to survey, compare and contrast physical and chemical properties of selected millet and sorghum/maize producing soils of West Africa. The sorghum/maize soils were found to have significantly higher organic matter content, ECEC, Fe and Al oxides, clay and P fixation capacity than their millet-producing counterparts. Major constraints to sustained production on both soils are wind and water erosion, low fertility, soil crusting and rapid percolation of water.

USAID Mission support for the second phase of IMAW (Integrated Management of Agricultural Watersheds) project has been approved (7/91) at a funding level of $500,000 for a two-year period. During this reporting period, the IMAW proposal was modified and re-submitted with additional information in order to acquire

approval as a contract directly with the USAID Mission in Niger.

Finally, a joint effort of four TropSoils universities is the ongoing preparation for an international workshop relating to TropSoils phosphorous decision support systems. This workshop is planned to be held on March 11-12, 1992, in College Station, Texas.

2. Technical support for research networks in the humid tropics.

Constraints addressed: Number and diversity of users, number and diversity of soils, information knowledge gap, lack of skills and research capabilities.

Project leader: T. J. Smyth, NCSU

Research collaborators by institution:

National research institute scientists in Guatemala, Honduras, Costa Rica, Panama, Venezuela, Ecuador, Colombia, Peru, Bolivia, and Brazil
S. W. Buol, NCSU
J. A. Alegre, NCSU
C. A. Palm, NCSU
F. R. Cox, NCSU
R. S. Yost, UH
W. R. Raun, formerly CIMMYT
H. J. Barreto, CIMMYT

PROJECT PROGRESS REPORT

A three-member editorial committee, comprised by scientists from CIMMYT, NCSU and the University of Costa Rica, edited and typeset the 37 manuscripts on network research reports and invited speaker presentations from the Latin American Tropical Soil Management Workshop, held July 8-14, 1990, in San Jose, Costa Rica. Distribution of the Spanish version of the proceedings was initiated 15 months after the workshop. The task of translating and typesetting of the English version is 50 percent complete.

National institute collaborators are continuing existing network trials to their final objectives. Results from paddy rice research by EMBRAPA on alluvial soils near Manaus, Amazonas, led to the development of on-farm demonstration trials sponsored by the state government. New collaborators from INTA at Corrientes, Argentina, have established international linkages and

developed plans to initiate the RISTROP experiment directed towards improved fertilizer N use efficiency in paddy rice systems. With support funds from INPOFOS (Instituto de la Potasa y el Fosforo), IDIAP collaborators have initiated a long-term trial directed towards comparisons of fertilizer P placement methods, application frequency and residual effects in Ultisols with high P fixation constraints in Santiago Province, Panama. Plans were developed and initiated for Texasgulf-sponsored collaborative research in Honduras, Costa Rica and Panama on agronomic effectiveness comparisons between triple-super and North Carolina PR and improved soil test P interpretations for soils derived from volcanic ash.

At the request of the Smithsonian Tropical Research Institute, a short-term (one week) assessment was performed on the national institute capabilities and potential research program strategies which could be used to mitigate deforestation problems in areas surrounding the Panama Canal Zone and adjacent National Forest Reserves and Parks.

3. Phosphorus decision support system.

Constraints addressed: There is widespread insufficiency of available soil phosphorus for maximum crop production in tropical environments. In many regions, phosphorus soil tests have not been calibrated for all combinations of crops and soils. Phosphorus recommendations are not as appropriate as they might be if soil particle size and clay mineralogy were taken into consideration in developing the recommendation.

Project leaders: Russell S. Yost, UH
Fred Cox, NCSU
Shaw Reid, CU
Art Onken, TAMU

Research collaborators by institution:

Ibere Lins, Campo Grande, Brazil
Puntipa Vichiensanth, Khon Kaen, Thailand
B. T. Kang, IITA, Nigeria
I Putu Gedjer Widjaja-adhi, Bogor, Indonesia

PROJECT PROGRESS REPORT

The first phosphorus decision support system workshop, held March 21, 1990, brought together interested researchers from the four TropSoils universities to develop plans for the computer system. The broad

structure of the decision-making procedure was determined: we decided to use a diagnosis-recommendation approach. This approach can be highly "information efficient", which means that it takes full advantage of common, widely available knowledge before asking for detailed, more expensive information. An illustration might be that if maize yields were extremely high, e.g. greater than 12 tonnes/ha, then phosphorus deficiency is unlikely and we need not collect and analyze numerous soil and plant samples, unless there are unusual circumstances.

Data necessary for the diagnosing of P deficiency was assembled from Sitiung, Indonesia; Brasilia, Brazil; Manaus, Brazil; Niamey, Niger; and Bamako,Mali, for use in diagnosis and recommendation. Major gaps in both the measurement of critical level and P fertilizer factor (P required to increase soil test P by one unit) became apparent. Because the traditional method of field calibrating soil tests for two to three years was not a viable option in these locations without such data, an attempt is being made to predict the P fertilizer factor.

Current developments in clay mineralogy analysis and modeling suggest some possibility of predicting P sorption from estimates of amount of surface area and P-sorbing hydroxyl density on the surface.

An economic analysis approach was identified that evaluates P residual effects, fertilizer materials suitability, and crop response to P, and suggests an optimal combination of these factors for profitability given various farmer scenarios. This approach is being evaluated for possible linkage with the recommendation to provide the necessary economic evaluation of alterative management choices.

The second workshop is being planned for March 11, 12, 1992, at College Station, Texas. The workshop objective is to review diagnostic procedures for the various sites, evaluate progress and research plans on predicting the calibration of phosphorus, evaluate the proposed economic analysis approach, consider how to include rock phosphate as a recommendation, and decide how to include an evaluation of potential to harm the environment through fertilizer excess. In contrast to the previous workshop, several collaborators will be attending and manuscripts will be presented.

VII. APPENDIXES

A. Graduate Student Thesis Completed

1. Natural Resource Management

Heil, Justin. 1990. Soil properties influencing hydraulic sealing of the surface on Alfisols in the Sahel. Advisors: A. S. R. Juo and K. McInnes. Ph.D. Texas A&M University.

Coulombe, Clement. 1990. Structural degradation/rejuvenation processes of Vertisols of Cameroon, Africa. Advisor: L. P. Wilding. Ph.D. Texas A&M University.

Hopper, J. W. 1990. The effect of farmer-built filtrating dike systems on increasing soil fertility and reversing soil degradation in the Sahel-Sudanian zone of West Africa. Advisor: S. W. Buol. M.S. North Carolina State University.

Rusman, Bujang. 1990. Perbaikan beberapa sifat kimia dan kandungan air tanah podsolik merah kuning Sitiung dengan pemberian kapur pada berbagai kedalaman serta efeknya terhadap perakaran dan hasil jagung. Advisor: Didin Suwandi Satiaatmadja. Ph.D. Universitas Padjadjaran, Bandung, Indonesia.

Kasli. 1991. Pertumbuhan dan hasil tanaman kacang hijau No. 129 pada tanah podsolik merah kuning (Ultisol) Sitiung yand diberi pupuk organik dan kapur. Advisor: Didin Suwandi Satiaatmadja. Ph.D. Universitas Padjadjaran, Bandung, Indonesia.

2. Sustainable Agriculture Production

Lu, Shaoliang. 1991. Correcting soil acidity using crop residues. Advisor: N. V. Hue. M.S. University of Hawaii.

Takow, J. 1991. Phosphorus, Mn and Fe relations in flooded soils in Cameroon, Advisor: L. R. Hossner. Ph.D. Texas A&M University.

Nurwakera, J. 1991. Soil phosphorus dynamics during continuous cultivation in a Brazilian Amazon Oxisol. Advisor: T. Jot Smyth. M.S. North Carolina State University.

Beck, M. 1991. Inorganic and organic phosphorus transformation during 18 years of cultivation in the

Amazon Basin. Advisor: Pedro A. Sanchez. M.S. North Carolina State University.

Salazar, A. A. 1991. Phosphorus fertilization on alley cropping systems in the Peruvian Amazon Basin. Advisor: C. A. Palm. M.S. North Carolina State University.

Cahn, Michael. 1991. Cation and nitrate leaching in an Oxisol of the Brazilian Amazon. Advisor: D. R. Bouldin. Ph.D. Cornell University.

B. Graduate Student Thesis Work in Progress

1. Natural Resource Management

Salazar, Angel. Thesis subject not selected. Advisor: A. G. Wollum. Ph.D. candidate. North Carolina State University.

Agus, Fahmuddin. Variability of soil properties in a contour hedgerow on a sloping Ultisol. Ph.D. candidate. Advisor: D. K. Cassel. North Carolina State University.

Matungulu, K. Characterization and fertility evaluation in some major soil groups in Zaire. Advisor: S. W. Buol. Ph.D. candidate. North Carolina State University.

Johnson, B. Soil spatial diversity and its limitations to land-use in Ranomafana Park, Madagascar. Advisor: S. W. Buol. Ph.D. candidate. North Carolina State University.

Monteith, S. Soil properties and distribution in the Chapare region of Bolivia. Advisor: S. W. Buol. Ph.D. candidate. North Carolina State University.

Muamba, F. Soil conditions resulting from incubation of surface soil samples of contrasting organic matter content and type. Advisor: S. W.Buol. M.S. candidate. North Carolina State University.

Dierolf, Thomas S. Soil water movement and base cation transport in a highly-weathered soil. Advisor: R. S. Yost. Ph.D. candidate. University of Hawaii.

McIntyre, Beverly. Soil water use by C_4 cereals grown in the semi-arid tropics. Advisor: Susan J. Riha. Ph.D. candidate. Cornell University.

Bilders, Charles. No title available. Advisor: Philippe Baveye. Ph.D. candidate. Cornell University.

Sow, Abdoul A. Tillage and residue effects on water extraction, rooting depth and soil temperature of dryland sorghum. Advisor: L. R. Hossner. Ph.D. candidate. Texas A&M University.

Schwartz, Robert C. Air flow and shear stress modifications resulting from annual wind barriers. Advisors: A. S. R. Juo and B. L. Harris. M.S. candidate. Texas A&M University.

Glasener, Karl. No title available. Advisor: Mike Wagger. M.S. candidate. North Carolina State University.

Castilla, C. Carbon and root dynamics in legume-based pastures. Advisor: Pedro A. Sanchez. Ph.D. candidate. North Carolina State University.

Luna-Orea, P. Managed fallows in low-input systems in Bolivia. Advisor: M. Wagger. Ph.D. candidate. North Carolina State University.

Ruiz, Pedro. Fractionation of P on agroforestry systems. Advisor: C. B. Davey. Ph.D. candidate. North Carolina State University.

Triomphe, Bernard. Mineralization-immobilization during mineralization of green manures. Advisor: D. R. Bouldin. Ph.D. candidate. Cornell University.

Fruci, Jean. No title available. Advisor: John Duxbury. Ph.D. candidate. Cornell University.

2. Sustainable Agriculture Production

Licudine, Danilo. Organic and inorganic chemistry of aluminum detoxification. Advisor: N. V. Hue. Ph.D. candidate. University of Hawaii.

Thompson, Marc. The effect of land modification on soil productivity and crop performance on selected hillside farms in souther Honduras. Advisor: A. S. R. Juo. M.S. candidate. Texas A&M University.

Doumbia, Mamadou D. Nutrient deficiency and toxicity studies at the Cinzana Station, Mali. Advisor: Lloyd R. Hossner. Ph.D. candidate. Texas A&M University.

Grahammer, Kathrine. Release of carbon and nitrogen during decomposition of millet residue and cowpea green manure during the rainy season in Niger. Advisors: A. S. R. Juo and R. W. Weaver. Ph.D. candidate. Texas A&M University.

Zaonge, Christophe. Interactive effects of water and nutrients on sorghum and cowpea growth in a Sahelian soil-plant-atmosphere continuum. Advisors: A. S. R. Juo and C. Wendt. Ph.D. candidate. Texas A&M University.

Verburg, Kirsten. No title available. Advisor: Philippe Baveye. Ph.D. candidate. Cornell University.

Marcano-Martinez, Eugenio. No title available. Advisor: Philippe Baveye. Ph.D. candidate. Cornell University.

Duron-Andino, Elio. Comparison of fertilizer P sources in Central American soils derived from volcanic ash. Advisor: T. J. Smyth. Ph.D. candidate. North Carolina State University.

Jackman, James. Kinetic rates of phosphorus sorption in soils of various mineralogies. Advisor: Russell Yost. M.S. candidate. University of Hawaii.

Guo, Fengmao. Predicting the nonlabile, reversible pool of phosphate in soils of varying residual value. Advisor: Russell Yost. M.S. candidate. University of Hawaii.

C. Publications in Serial Journals, Technical Bulletins, Monographs and Workshop Proceedings

1. Natural Resource Management

Geiger, S. C., A. Manu and A. Bationo. 1991. Chemical properties of a sandy sahelian soil following five years of crop residue and fertilizer addition. Soil Sci. Soc. Am. J. (in press).

Manu, A., A. Bationo and S. C. Geiger. 1991. Fertility status of selected millet producing soils of West Africa with emphasis on phosphorus. Soil Sci. 152:315-320.

Buol, S. W. 1990. Spodosols in the tropics. pp 41-45. *In* J. M. Kimble and R.D. Yeck (eds.) Proceedings of the Fifth International Soil Correlation Meeting

(ISCOMIV) Characterization, Classification and Utilization of Spodosols. USDA-SCS, Lincoln, NE.

Arya, L. M., Z. Zaini and T. S. Dierolf. 1990. Characteristics of acid soils in Sumatra and their relative suitability for production of food crops versus forages. Paper presented at the International Workshop on Integrated Tree Cropping and Small Ruminants Production Systems, Medan, North Sumatra. September 10-15, 1990.

Arya, L. M., T. S. Dierolf, A.Sofyan, and I. P. G. Widjaja-Adhi. 1991. Field measurement of saturated hydraulic conductivity in a highly-weathered, macroporous Ultisol in Sitiung, Indonesia. Paper to be submitted to the Soil Science Society of America Journal.

Evensen, C., T. Dierolf and R. Yost. 1991. alley-farming on highly-weathered soils: Cumulative effects on yield and soil properties. American Society of Agronomy Meetings, Denver, Colorado. October 27--November 1, 1991.

2. Sustainable Agriculture Production

Hue, N. V., R. L. Fox and J. D. Wolt. 1990. Sulfur status of volcanic ash-derived soils in Hawaii. Commun. Soil Sci. Plant Anal. 21:299-310.

Payne, W. A., R. J. Lascano, L. R. Hossner and C. W. Wendt. 1991. Pearl millet growth as affected by phosphorus and water. Agron. J. 83:942-948.

Takow, J. A., M. D. Doumbia and L. R. Hossner. 1991. Acid soil profiles of the semiarid and subhumid tropics in Central and West Africa. *In* R. J. Wright et al. (eds.), Plant-soil interactions at low pH. Kluwer Academic Publ., The Netherlands. P. 313-320.

Alegre, J. C. and P. D. Lara. 1991. Efecto de los animales en pastoreo sobre las propiedades fisicas de suelos de la region tropical humeda del Peru. Pasturas Tropicales, Vol. 13, No. 1. pp. 28-34.

Alegre, J. C. and D. K. Cassel. 1991. Conservation tillage in the humid tropics of Peru. Proceedings of 12th International Conference Soil Tillage and Agricultural Sustainability, Ibadan, Nigeria. pp. 335-343.

Alegre, J. C., D. K. Cassel and E. Amezquita. 1991. Tillage systems and soil properties in Latinamerica. Soil and Tillage Research. 20:147-163.

Alegre, J. C. and R. Chumbimune. 1991. Investigaciones y usos de la Roca Fosforica en el Peru. Memorias, de las II Reunion de las Red Latinoamericana de Roca Fosforica, San Cristobal, Edo. Tachina, Venezuela.

Elliot, E. T., C. A. Palm, D. E. Reuss and C. A. Munz. 1991. Organic matter contained in soil aggregates from a Tropical chronosequence: connection for sand and light fraction. Agriculture, Ecosystems and Environment. 34:443-451.

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D. Special and Miscellaneous Reports Published

1. Natural Resource Management

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Manu, A., et. al. 1991. Integrated management of agricultural watersheds (IMAW) - characterization of a research site near Hamdallaye, Niger. TropSoils Bulletin No. 91-03, Soil Management CRSP, North Carolina State University, Raleigh, NC.

Taylor-Powell, E. 1991. Integrated management of agricultural watersheds: Indigenous knowledge of soil and land management. TropSoils Bulletin No. 91-04, Soil Management CRSP, North Carolina State University, Raleigh, NC.

Bationo, A., K. K. Lee, A. Manu, M. C. Klaij and S. Geiger. 1991. The status and role of crop residue in sustaining crop production in sandy Sahelian soils of West Africa. Paper presented at the International Workshop on Dynamics of organic matter in relation to the sustainability of agricultural systems. Leuven-Belgium, November 3-6, 1991.

Beidari, F., A. Berrada, A. Manu, M. Bachir and M. G. Gaoh. 1991. Soil phosphorus tests on millet producing soils of western Niger. Agronomy Abstracts, p. 282. Presented to Division S-4, ASA Annual Meeting, Denver, Colorado. October 27--November 1, 1991.

Berrada, A., M. G. Gaoh and S. Geiger. 1991. A geostatistical study of spatial variability of millet growth in Niger. Agronomy Abstracts, p. 59. Presented to Division A-6, ASA Annual Meeting, Denver, Colorado. October 27--November 1, 1991.

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2. Sustainable Agriculture Production

Hue, N. V. 1990. Correcting soil acidity of a highly weathered Ultisol with chicken manure and sewage sludge.

Wolt, J. D., N. V. Hue and R. L. Fox. 1990. Sulfate sorption-desorption characteristics of three sulfur-retentive Hydrandepts of the island of Hawaii.

Kouyate, Z. and C. W. Wendt. 1991. Gestion de l'ean et de la fertilite' du sol au Mali. *In* Soil Water Balance in the Sudano-Sahelian Zone. Proceedings of the Niamey Workshop, February, 1991. M. V. K. Sivakumar, J. S. Wallace, C. Renard and C. Girous (editors). IAHS Publ. No. 199, p. 339-344.

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3. Outreach

Smyth, T. J., W. R. Raun and F. Bertsch (eds.). 1991. Manejo due suelos tropicales en Latinoamerica. Memorias del II Taller Latinoamericano de Manejo de Suelos Tropicalses, San Jose, Costa Rica, 9-13 de julio, 1990. North Carolina State University, Raleigh, NC. 320 p.

Yost, Russell. Status report of the Phosphorus Decision Support System, March 1990. 12 pp.

E. Papers, Posters, etc., Presented at Professional Meetings

1. Natural Resource Management

Coulombe, C. E., J. B. Dixon and L. P. Wilding. 1991. Mineralogical and physico-chemical properties of Vertisols in relation to soil utilization. Agronomy Abstracts, p. 364-365. Presented to Division S-9, ASA Annual Meeting, Denver, Colorado. October 27--November 1, 1991.

Wilding, L. P. and C. E. Coulombe. 1991. Expansive soils: distribution, morphology and genesis. NATO - Advanced Research Workshop on Clay Swelling and Expansive Soils, Cornell University, Ithaca, NY. August 12-16, 1991.

Drees, L. R. and A. Manu. 1991. Uric acid dihydrate in atmospheric dust collected in Niger, West Africa. Agronomy Abstracts, p. 365. Poster presentation, Division S-9, ASA Annual Meeting, Denver, Colorado. October 27--November 1, 1991.

Juo, A. S. R. 1991. Characterization and evaluation of soils in relation to crop production with special references to Africa. Invited paper. United Nations University National Resources Workshop, Nairobi, Kenya. August 11-16, 1991.

Wilding, L. P., A. Manu, L. R. Drees, P. Sankara and O. Smith. 1991. Soil resources evaluation of Peanut CRSP sites in Burkina Faso. Agronomy Abstracts, p. 67. Presented to Division A-6, ASA Annual Meeting, Denver, Colorado. October 27--November 1, 1991.

Matungulu, K. M., S. W. Buol and P. A. Sanchez. 1991. Characterization and fertility evaluation of some major soil groups from Zaire (Africa). *In* Agron. Abstracts, 1991 Annual Meetings, Denver, CO, October 27--November 1. American Society of Agronomy, Madison.

Dierolf, T. S., L. M. Arya, I. P. G. Widjaja-Adhi and A. Sofyan. 1991. Soil structure effects on water flow in highly-weathered Ultisols and implications for soil fertility. Paper presented close of service seminar in Bogor, Indonesia. July 10, 1991. (To be included in Proceedings of the Center for Soil and Agroclimate Research 1991 Technical Meeting).

Dierolf, T. S., L. Arya, I. P. G. Widjaja-Adhi and R. Yost. 1991. Nutrient cation movement in highly weathered soils. Poster presented at ASA Annual Meeting, Denver, Colorado. October 27--November 1, 1991.

Riha, S. J., D. G. Rossiter and I. W. Buttler. 1990. GAPS: A flexible simulation model of the atmosphere-plant-soil system. Abstract, American Society of Agronomy Annual Meetings, San Antonio, Texas.

McIntyre, B., D. Flower and S. J. Riha. 1991. Stress and water uptake in millet in northern Nigeria. International Symposium on Physiology and Determination of Crop Yields. Sponsored by ASA and USDA-ARs. Gainesville, FL. June.

2. Sustainable Agriculture Production

Lu, Z. and N.V. Hue. 1990. Correction soil acidity using crop residues. ASA Poster Session: Soil Acidity and Liming. San Antonio, Texas.

Wolt, J. D., N. V. Hue and R. L. Fox. 1990. Sulfate sorption-desorption characteristics of three sulfur-retentive Hydrandepts from Hawaii. ASA Poster Session: Oxyanion Kinetics and Adsorption. San Antonio, Texas.

Juo, A. S. R. and R. C. Schwartz. 1991. Managing natural resources for sustained sorghum and millet production. Invited paper. International Sorghum and Millet Workshop, Corpus Christi, Texas. July 8-13.

Grahammer, K., R. W. Weaver and A. S. R. Juo. 1991. Nitrogen released from ^{15}N-labelled cowpeas during decomposition in soil. Agronomy Abstracts, p. 288. Poster presentation, Division S-4, ASA Annual Meeting, Denver, Colorado. October 27--November 1, 1991.

Kouyate, Z. and C. W. Wendt. 1991. Water and fertility management in Mali (abstract). *In* Soil Water Balance in the Sudano-Sahelian Zone. Proceedings of the Niamey Workshop, February 1991. M. V. K. Sivakumar, J. S. Wallace, C.Renard and C. Girous (editors). IAHS Publ. No. 199, p. 616.

Alegre, J. C. 1991. Runoff and erosion losses under forest, low-input and alley cropping on slopes in the humid tropics of Peru. p. 58. *In* Agron. Abstracts, 1991 Annual Meetings, Denver, CO, October 27--November 1. American Society of Agronomy, Madison.

Beck, M. and P. A. Sanchez. 1991. Inorganic and organic soil phosphorus dynamics during 18 years of cultivation in the Amazon Basin. p. 282. *In* Agron. Abstracts, 1991 Annual Meetings, Denver, CO, October 27--November 1. American Society of Agronomy, Madison.

Glasener, K. and C. A. Palm. 1991. Ammonia volatilization from tropical legume mulches. p. 61. *In* Agron. Abstracts, 1991 Annual Meetings, Denver, CO, October 27--November 1. American Society of Agronomy, Madison.

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Glasener, K. M. and C. A. Palm. 1991. Ammonia volatilization from tropical legume mulches. p. 61. *In* Agron. Abstracts, 1991 Annual Meetings, Denver, CO, October 27--November 1. American Society of Agronomy, Madison.

3. Outreach

Bationo, A., A. Manu, A. V. Mokwuyne. 1991. Soil chemical properties of sandy sahelian soils as affected by different management practices and their impact on pearl millet yields. ASA Annual Meetings, Denver, CO. October 27--November 1.

Manu, A. 1991. Soil degradation in the sahel. Presented to a seminar workshop entitled "The State of Environmental Degradation in Niger." Sponsored by the Organization of Nigerian volunteers for the Preservation of the Environment. Tahoua. June 30--July 6.

Manu, A., A. Bationo, A. V. Mokwuyne. 1991. Comparative study of millet and corn/sorghum soils from selected West African countries. ASA Annual Meetings, Denver, CO. October 27--November 1.

Yost, Russell. 1990. An inconsistency in modeling phosphorus management in tropical soils. Poster presented at the 1990 American Society of Agronomy Meetings, San Antonio, Texas.

Yost, Russell. 1991. A status report of the Phosphorus Decision Support System. Presented at the Western Regional Phosphate Conference, Fort Collins, CO. March 22-24.

F. Special Activities Related to the Management of Tropical Soils

1. Natural Resource Management

Dr. A. S. R. Juo was invited by the United Nations University, Natural Resources Program for Africa to deliver three lectures on watershed management and soil characterization at a UNU Workshop held in Nairobi, Kenya, August 11-16, 1991. the workshop was attended by researchers from the Research and Training Network of the UNU Natural Resource Management Program.

Dr. S. W. Buol lecture to Sustainable Agriculture Training Session at IFDC, Muscle Shoals, Alabama.

October 8, 1991. Title: Soils of the tropics and subtropics and their uses.

Dr. S. W. Buol lecture to class at Duke University Institute for learning in retirement. October 1, 1991. Title: People adopting to soils.

Dr. S. W. Buol lecture to ENCORE program at NCSU September 25, 1991. Title: Tropical deforestation alternatives.

Dr. Lalit Arya. A group of scientists and technicians from the Sukarami Research Institute for Food Crops received field and laboratory training in measuring soil physical properties and processes.

Mr. Yoyo, an employee of the Indonesian Atomic Energy Agency and a graduate student at the Agricultural University, Wageningen, Netherlands, conducted his field research with assistance from TropSoils Project in Sitiung.

2. Sustainable Agriculture Production

Robert Caldwell and Paul Singleton. Development of the Crop Sys. Computer model. On September 16, 1991, a newsletter was mailed to 44 scientists who have expressed interest in the project. The mailing list included representatives from the major international research centers and number of national programs. Research progress was described int he letter, and a request was made for additional collaborative linkages. Scientists from CIAT, ICRISAT, and a development project in Indonesia have responded with requests for further dialogue.

Drs. R. Hanson, A. S. R. Juo and H. van Es visited Honduras June 16-23, 1991, to discuss long-term collaborative programs with officials from the Honduran Ministry of Natural Resources (SRN), USAID/LUPE project personnel and representatives from the Pan American School of Agriculture.

Drs. A. S. R. Juo, A. Onken and R. G. Hanson attended the INTSORMIL "International Sorghum and Millet Workshop, July 8-12, 1991, Corpus Christi, Texas.

Schwartz, R. 1991. Wind barrier design criteria. Wind Erosion Prediction System Core Team Meeting, Big Spring Texas, November 19-21, 1991.

3. Outreach

Manu, A. TropSoils/TAMU/Niger field tours of demonstration activities were conducted by TropSoils/Niger staff for USAID/Niamey representatives, members of the International Soil Tillage Research Organization and farmers within the watershed.

Since the air-layering of *A. senegal* generated interest among local villagers, a short training session pertaining to the technique was given to a local group at Hamdallaye.

Dr. Lalit Arya. Problems of crop water availability and implications of rapid water flow on soil fertility in Sitiung soils were presented in several formal discussions and a seminar at the Sukarami Research Institute for Food Crops.

TropSoils research activities and achievements were presented to a INSURF/IRRI meeting in Padang.

Properties and processes in acid upland soils in Sumatra and their management for crop production were presented in a seminar at the Central Crops Research Institute, Bogor.

The above topic was also presented in a seminar at the Center for Soil and Agroclimate Research, Bogor.

Accomplishments of TropSoils Project, ongoing activities, and recommendations were presented to the USAID Mission in Jakarta.

Dr. N. V. Hue. Special activities related to tropical soil management: Sabbatical leave ind Thailand and Vietnam from July 1991--November 1991.

Alegre, J. C. Seminar: Soil Management for Intensive Continuous Cropping. Agrarian University of Managua, Nicaragua.

Alegre, J. C. Seminar: Management of Acid Soil with Different Technological Options. Agraria University, La Molina, Lima, Peru.

Alegre, J. C. Workshop on Nutrient Cycling: Physical limitation of tropical soils under grazing. CIAT, Cali, Colombia

Dr. A. Manu participated in an international workshop on Soil Water Balance in the Sudano-sahelian Zone. Niamey, Niger, February 18-22, 1991.

Dr. A. Manu participated as team leader for the design of a USAID funded Mali SPARC project, September 10 to November, 1991.

Dr. A. S. R. Juo visited Jamaica at the invitation of the Jamaican Agricultural Foundation (July 16-20, 1991) to discuss potential TropSoils outreach and join graduate programs in the Caribbean.

Dr. T. Jot Smyth. Educational activities--five days of lectures on tropical soil management to Asian and African agronomist during the CIMMYT-sponsored six-week course on research design and management for national institute collaborators in the Maize Program. El Batan, Mexico. October 13-18, 1991.

Presentations--seminar for CIMMYT staff on TropSoils' Global Research Plan. El Batan, Mexico. October 15, 1991.