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Executive Summary Report

Program Year Nine
1989–1990

TropSoils
The Soil Management Collaborative
Research Support Program

Management Entity Office
North Carolina State University
Raleigh, NC 27695-7113

Collaborating Organizations

U. S. Government

United States Agency for International Development
Bureau of Science and Technology

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

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I. EXECUTIVE SUMMARY

The 1989-90 program year was Year Nine of the Soil Management CRSP (TropSoils) and Year One of the present grant extension. The year was filled with many programmatic and operational changes being completed and put in place.

The programmatic changes mandated were to move to more cross-cutting research activities focused on constraints identified in the global plan. This was completed with four planning workshops in: 1) Natural Resource Management; 2) Low-Input Sustainable Systems; 3) Phosphorus Decisions Support Systems; and 4) Nitrogen Decision Support Systems. These activities were completed with submission of cross-cutting projects.

Based on a study of operations and a need to develop a new activities budgeting system, a White Paper was prepared for the Executive Committee of the Board of Directors, Technical Committee, External Evaluation Panel and campus administrators on CRSP expenditures. To separate out operational costs and research activities costs, there was a call for new projects in which primary site management and backstopping projects with budgets were included.

Two new External Evaluation Panel members were selected (Dr. Clarence C. Gray III and Dr. William E. Larson), and orientation meetings of the three member Panel were held. Their first task was to review the submitted research and operational proposal and provide recommendations and suggestions to the CRSP on which funding decisions could be guided. From these and internal factors, funding on project bases was completed. Funds were disbursed based on completion of Annual Activities Work Plans and Budgets. This moves TropSoils more into cross-cutting activities funding in compliance with the JCARD/BIFAD mandate and CRSP operations.

Much progress was made in completing the biennial Technical Report with three of the four universities meeting the deadline. This lapse has caused unwarranted delay and notification that vouchers would not be honored by AID. A technical bulletin on green manures was completed and distribution initiated.

There were 24 publications in serial journals, technical bulletins, monographs and workshop proceedings of which six were natural resource management and 18 on sustainable agriculture. Twenty-six special and miscellaneous publications were completed, nine on natural resource management and 17 on sustainable agriculture. Seventy-seven papers, posters, etc., were presented at professional meetings; 10 on natural resource management; 20 on sustainable agriculture development; and 47 under outreach, principally during the RISTROP workshop on July 6-14, 1991, in

Costa Rica. A number of special activities and presentation requests were also completed. The Director of the Management Entity office presented seminars on the Soil Management CRSP programs and activities at the International Fertilizer Development Center-Alabama, Universities of Missouri and Minnesota and the Indian Council of Agriculture Research (ICAR), New Delhi, India.

New thrusts completed included the feasibility study for the Integrated Management of an Agricultural Watershed (IMAW) in Niger. An implementation grant has been submitted to USAID/Niamey Mission. This land management unit approach to combining sustainable agriculture interventions in a natural resource setting has caught the imagination of others and could lead to new opportunities for TropSoils.

Graduate training continued during the past fiscal year. Nine graduate students completed their degrees; three in natural resource management (all Ph.D.s); six in sustainable agriculture (five Ph.D.s and one M.S.). There are 23 graduate students in their degree programs: 11 in natural resource management (10 Ph.D.s and one M.S.); 12 in sustainable agriculture (eight Ph.D.s and four M.S.). Extramural funding seeking to bring more students into the program was a continuous effort throughout the year. TropSoils looks for many of these students to be future collaborators.

A general Memorandum of Understanding was signed with the International Rice Research Institute during the fiscal year. This will open the door for some new program opportunities for TropSoils, especially in graduate student education and thesis research.

The Director of the Management Entity office was involved in activities of the newly formed CRSP Council during 1989-90. He is serving on a two-member ad hoc committee drafting and completing the By-Laws and general Memorandum of Understanding. The Council presents CRSP activities programs to congressional aides, AID administrators (bureaus and upper management), World Bank and environmental groups. These activities help save the CRSPs funding base and establish solidarity , visibility and creditability.

The socio-economic activities were considerably beefed up with a two-year, $200,000 grant, "Socio-Economic Impact Analysis of the Technologies Generated by the Soil Management and Other CRSPs in the Humid Tropics." Major focus will be on the humid tropics in Central and South America and Asia because there is very little CRSP activities in the humid tropics in Africa. The impact study will focus on identifying sustainable systems technology in natural resource setting.

The ninth year was filled with adventures, change and more acceptance in the international science community. It was truly a busy and demanding year on all the contributors.

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 1989-90 fiscal year concentrated in the agroecological zones and countries:

Humid Tropics - Peru, Indonesia, Brazil
Semi-Arid Tropics - Niger, Mali
Savannas - Nigeria

With two graduate students completing their field research, all Soil Management CRSP support operations in Brazil were terminated.

The collaborating institutions during the 1989-90 fiscal year were:

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

Indonesia - Center for Soils and Agroclimatic Research (CSAR)

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

Mali - Institut d'Economie Rurale (IER)

Nigeria - International Institute for Tropical Agriculture (IITA)

Brazil - Empresa Brasileira de Pesquisa Agropecuaria (EMBRAPA-terminated in 1990)

The Memorandum of Understanding (MOU) signed with Institute of Agronomy Research (IRA) was not moved to an operational Memorandum of Agreement.

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)

Responding to a request from the Director General of INRAN to develop a technical base for land-use policies for the country of Niger, Texas A&M, under grant support from the USAID/Niamey Mission served as leader of the feasibility study. This was an interdisciplinary project utilizing biologist from the University of Niamey, socio-anthropologist consultant, soil scientist using the natural resource management approach. The base line, physical and socio-anthropological studies were completed and incorporated into a feasibility study.

The Phase II, implementation, was submitted from the USAID/Niamey Mission to AID/W for a buy-in under the TropSoils Basic Ordering Agreement (BOA) in April 1990. On January 30, 1991, the implementation phase as a BOA was formally rejected by AID/W.

V. SOIL MANAGEMENT CRSP ADMINISTRATION

The Management Entity and office of the Management Entity is at North Carolina State University. The four participating universities, Cornell University, University of Hawaii, North Carolina State University and Texas A&M University, each have one voting member on the Board of Directors (BOD) and the Technical Committee (TC). For outside monitoring, the CRSP utilizes a three professional External Evaluation Panel (EEP). There were no changes in the BOD and TC in 1989-90. Two new members were brought on board the EEP: Dr. William E. Larson, Soil Scientist with the University of Minnesota, and Dr. Clarence C. Gray III, Professor Emeritus, Virginia Tech.

A. External Evaluation Panel Briefing

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 newly formed EEP met with the Director of the Office of the Management Entity; AID Project Officer; AID Director, Office of Agriculture, Bureau for Science and Technology;, and other CRSP project officers to become

acquainted with CRSP guidelines and responsibilities of the EEP.

B. CRSP Special Planning 1989

1. Cross-Cutting Projects

To complete recommendations by JCARD and BIFAD cross-cutting program planning in natural resource management, sustainable agriculture production and Decision Support Systems in phosphorus and nitrogen management were completed. This would require rewrite of all CRSP projects to update the portfolio.

a. Natural Resource Management

Principal investigators from three of the four universities met at Texas A&M University and prepared a comprehensive research proposal on the processes of soil degradation and rejuvenation.

b. Low-Input Sustainable Agriculture

Principal investigators from the four universities met at North Carolina State University and drafted a proposal on organic matter and nitrogen management for low-input sustainable agriculture systems in the tropics.

c. Decision Support Systems

Principal investigators from the four universities participated in a Phosphorus Decision Support System Workshop hosted by the University of Hawaii and a Nitrogen Decision Support System Workshop hosted by Cornell University. From these two workshops, cross-cutting proposals were prepared.

2. Project Rewrites

The 1989-94 grant approval was based on research proposals with a three-year horizon (1989-92). To complete a major contingency of JCARD/BIFAD, all projects were updated with the status of the CRSP budget and operations. The bases for this rewrite were guided by a "White Paper" prepared by the Director of the Office of the Management Entity to document past operational costs and how money was being utilized.

The project rewrite was completed in July 1990 reviewed by the EEP and general program recommendations were completed for the CRSP. Projects for approximately $3.5 million were received for the 1990-91 fiscal year, as the initial year of the move to activities integration. The BOD and TC met at Cornell University in September 1990, with guidelines provided by the EEP, completed allocation suggestions for the Director of the Office of the Management Entity. This is summarized in Table 1. It was

TABLE 1
SOIL MANAGEMENT CRSP - YEAR 10
BUDGET WORKSHEET

ACTIVITY	REQUEST	RECOMMENDED ALLOCATI TC	ME/BOD
A. COUNTRY PROGRAMS			
1. RESEARCH SITE OPERATIONS			
UHTS-01 Humid Tropics-Indonesia (Hawaii)	$231,450	$160,000	$160,000
TXTS-01 Semiarid Tropics-Niger, Mali (TAMU)	155,837	160,000	160,000
NCTS-01 Humid Tropics-Peru (NCSU)	297,400	160,000	160,000
TOTAL	$684,687	$480,000	$480,000
2. CAMPUS BACKSTOPPING			
UHTS-02 (Hawaii)	$ 78,210	$ 39,105	$ 39,105
TXTS-02 (TAMU)	76,424	76,424	76,424
NCTS-02 (NCSU)	70,500	60,000	60,000
TOTAL	$225,134	$175,529	$175,529
B. GLOBAL THRUSTS			
1. NATURAL RESOURCE MANAGEMENT			
NCSU-01 (Palm, Alegre, Szott)	$ 70,600	$ 65,000	$ 65,000
TAMU-05 (Juo, Manu)	-0-	-0-	-0-
UH-01 (Yost, Cochrane)	116,540	-0-	-0-
TAMU-01 (Juo, Wilding)	55,155	55,155	55,155
TAMU-04 (Wilding, Hossner)	27,350	27,350	27,350
NCSU-02 (Buol)	59,800	35,000	35,000
TOTAL	$329,445	$182,505	$182,505
2. SUSTAINABLE AGRICULTURE PRODUCTION			
UH-03 (Hue, I. Amien, Arya)	$ 34,620	$ 17,310	$ 17,310
UH-04 (Caldwell, Singleton)	49,540	24,770	24,770
UH-06 (Uehara, Gillman)	25,130	-0-	-0-
NCSU-03 (Davey, Palm, Salazar)	60,800	50,000	50,000
NCSU-04 (Sanchez, Smyth)	88,100	50,000	50,000
UH-05 (Habte)	21,940	-0-	-0-
UH-07 (Dieroff and others)	34,410	17,205	17,205
TAMU-03 (Hossner, Juo)	53,539	53,539	53,539
TAMU-06 (Onken)	5,160	5,160	5,160
TAMU-02 (Juo)	54,392	27,196	27,196
CU-02 (Duxbury)	59,273	59,273	59,273
CU-03 (Reid, Bouldin)	59,273	59,273	59,273
CU-01 (Riha)	67,845	67,845	67,845
TOTAL	$614,022	$431,571	$431,571

ACTIVITY	REQUEST	RECOMMENDED ALLOCATION TC	ME/BOD
3. OUTREACH			
TAMU-10 (Puentes, Juo)	$ 36,336	$ 36,336	$ 36,336
NCSU-05 (Smyth)	72,300	60,000	60,000
UH-02 (Widjaja-Adhi, Zaini, Arya)	9,750	-0-	-0-
TOTAL	$118,386	$ 96,336	$ 96,336
C. CROSS CUTTING PROJECTS			
PDSS-01 (UH-Yost)	$122,700	$ 61,350	$ 61,350
NDSS-01 (CU-Bouldin)	113,449	-0-	-0-
TOTAL	$236,149	$ 61,350	$ 61,350
TLIS-01			
UH (Fownes)	$ 70,600	$ -0-	$ -0-
CU (Duxbury)	110,400	-0-	-0-
NCSU (Sanchez)	103,800	-0-	-0-
TAMU (Hossner) (TAMU-02a)	106,900	27,196	27,196
TOTAL	$391,700	$ 27,196	$ 27,196
TNRM			
CU (Baveye, McBride) (CU-04)	$108,387	108,387	108,387
NCSU (Cassel)	66,352	-0-	-0-
TAMU (Wilding)	70,780	-0-	-0-
TOTAL	$245,519	$108,387	$108,387
D. COMMUNICATIONS			
COM-01 (Caudle)	$159,000	$150,000	$150,000
TOTAL	$159,000	$150,000	$150,000
E. PROGRAM MANAGEMENT			
Board of Directors Travel	$ 12,439	$ 12,439	$ 12,439
Technical Committee Travel	11,169	11,169	11,169
Ext. Eval. Panel (Travel and Services)	34,792	34,792	34,792
Management Entity	308,546	308,546	308,546
Reserve	65,000	26,054	26,054
TOTAL	$431,946	$393,000	$393,000
GRAND TOTAL	$3,435,988	$2,105,874	$2,105,874

voted at this time that line item budgeting for prime site operations for the 1991-92 fiscal year would be phased out by the end of 1990-91 fiscal year.

C. 1989-90 Expenditure Summaries

The 1989-90 fiscal year budget summary is presented in Table 2. Estimates for special planning functions supplied to the ME were much under the actual costs. This along with previous commitments required draw down from reserves for special projects costs for BOD and EEP came in under budget while TC costs came in over budget. Special costs for the ME Director, TC and BOD participation in CRSP Council activities came out of the small reserve held under other commitments.

D. Nine-Year Disbursement Summary

The nine-year summary of disbursement of CRSP are presented in Table 3. To bring the Soil Management CRSP in line with other CRSPs, the ninth 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 74 percent disbursement to the activities of the four participating institutions and 10.3 percent for the Director of the Office of the Management Entity.

E. Office of the Management Entity

The summary of expenditures by the Director of the Office of the Management Entity is presented in Table 4. Equipment purchased was to bring FAX on line (TropSoils was the only CRSP without a fax in the ME office). New and replacement of computer equipment and printer has streamlined a number of operations. Bringing in the software package WordPerfect 5.0 and phasing out WordStar 2000 makes the office of the ME compatible with donor agency and all four campuses. Computer equipment replaced was transferred to support graduate students needs of the Soil Science Department of North Carolina State University.

With new computer equipment in the ME office, plans are to bring CGNET and BINET to permit direct communication linkages with the other seven CRSPs, AID/S&T and CG Centers.

F. Miscellaneous Activities

An informal discussion/meeting session was organized by Dr. Ruben Puentes during the American Society of Agronomy (ASA) meeting in San Antonio, TX. Faculty, graduate students, graduates, IARC scientists and PVO representatives were present. Most would like a full-day meeting prior to the ASA meetings in Denver, CO.

TABLE 2

Soil Management CRSP Budget Summary

Year Nine: September 25, 1989 - September 24, 1990

Object	Proposed	Disbursement	Difference
A. Core			
Cornell	$ 270,810	$ 270,810	$ 0
Hawaii	258,400	258,400	0
NC State	421,855	421,855	0
Texas A&M	405,025	445,025	(40,000)
Communications	150,000	150,000	0
ME	235,675	235,675	0
Subtotal	$1,741,765	$1,781,765	($40,000)
B. Cross-Cutting Division			
Cornell	$ 23,762	$ 23,762	$ 0
Hawaii	22,807	22,807	0
NC State	37,137	37,137	0
Texas A&M	35,704	35,704	0
Subtotal	$ 119,410	$ 119,410	$ 0
C. Special Projects			
NDSS	$ 12,000	$ 12,000	$ 0
PDSS	31,000	31,000	0
NDSS (Terminal)	31,000	1,271	29,729
DSS Planning	5,800	15,665	(9,865)
ACID4 (1988 Commitment)	0	10,000	(10,000)
C&S Am. Planning	29,200	6,268	22,932
LIS & NRM Planning	10,900	14,466	(3,566)
Reserve	0	29,230	(29,230)
Subtotal	$ 119,900	$ 119,900	0
D. Other Commitments			
Board Meetings	$ 10,000	$ 5,316	$ 4,684
TC Meetings	10,000	7,048	2,952
EEP Travel, Services	11,625	6,809	4,816
Other Special Travel	0	1,955	(1,955)
Grad. Stu. (NCSU)	17,700	17,700	0
Grad. Stu. (Florida)	3,600	3,600	0
Indirect Cost	34,500	34,500	0
Reserve	31,500	41,997	(10,497)
Subtotal	$ 118,925	$ 118,925	$ 0
TOTAL	$2,100,000	$2,140,000	($40,000)

TABLE 3

Soil Management CRSP Disbursements 1981-1990

	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	Total
	($1,000)									
Cornell	-----	225	-----	336	395	443	352	319	308	2,378
Hawaii	-----	660	-----	716	675	454	353	303	322	3,483
N. C. State	-----	2,531	-----	1,028	1,090	651	522	514	481	6,817
Texas A&M	-----	1,152	-----	729	752	543	431	476	481	4,564
ME	-----	487	-----	417	480	387	306	292	222	2,591
Communications	-----	-----	-----	-----	-----	55	94	150	150	449
Cont/Plan/Sp. Requests/Reserve	-----	-----	-----	-----	-----	46	43	31	147	267
BOD	-----	-----	-----	-----	-----	-----	-----	-----	9	9
TC	-----	-----	-----	-----	-----	-----	-----	-----	10	10
EEP	-----	-----	-----	-----	-----	-----	-----	-----	10	10
	-----	5,055	-----	3,226	3,392	2,579	2,101	2,085	2,140	20,578

TABLE 4

MANAGEMENT ENTITY 1989-90 EXPENDITURES
September 25, 1989--September 24, 1990

I.	SALARIES AND BENEFITS		
	A. Salaries		
	Director	$70,035	
	Adm. Assistant	24,333	
			$ 94,368
	B. Benefits (23.9%)		
	Director	11,090	
	Adm. Assistant	5,982	
	Staff Benefits	507	
			$ 17,579
II.	OPERATIONS		
	A. Telephone and Fax	2,628	
	B. Postage--Mailings	1,131	
	C. Services/Rents/Repairs	1,910	
	D. Supplies	2,856	
	E. Equipment	18,440	
	F. Miscellaneous	131	
			$ 27,096
III.	TRAVEL AND RELATED EXPENSES		
	A. Director, Management Entity	$19,375	
	B. Board of Directors	5,316	
	C. Technical Committee	7,048	
	D. External Evaluation Panel	6,809	
	E. Related Travel Expenses	330	
			$ 38,878
IV.	INDIRECT COSTS		$ 72,278
	TOTAL		$250,199

VI. PROGRAM SUMMARIES

A. Natural Resource Management

Project Title: Development and evaluation of agroforestry systems for control of wind and water erosion and modification of microclimate. TAMU-404.

Constraints Addressed: Land clearing pressure
Landscape restrictions

Project Leaders by Institution:

A. S. R. Juo	TAMU/TAES
S. Geiger	TAMU/TAES
M. Hassan	INRAN (Niger)

Research Collaborators by Institution:

M. Gandah	INRAN (Niger)
M. Ouattara	INRAN (Niger)
M. Saadou	University of Niamey
A. Manu	TAMU/TAES
R. Puentes	TAMU/TAES
T. Thurow	TAMU/TAES
P. Felker	TAMU/TAES
M. Thompson	TAMU/TAES
R. J. Van den Beldt	ISC
C. Wendt	TAMU/TAES

PROJECT PROGRESS REPORT

Summary of Research

Increased population pressure coupled with climatic changes in recent decades have resulted in severe land degradation, water and wind erosion, and loss of abundance and diversity of natural vegetation in the African SAT. TropSoils is conducting systematic long-term research aimed at developing effective agroforestry-related practices for land rejuvenation. Project TAMU-404 included six experiments/activities initiated in 1990. Most of the work was conducted at Hamdallaye, Niger; a description of the watershed is reported in project TAMU-406.

1. Biodiversity inventory of the Hamdallaye watershed.

2. Analysis of soil variability and growth of Acacia albida.

3. Natural revegetation of laterite plateau at Hamdallaye.

4. Gully control at Hamdallaye.

5. Windbreaks for wind erosion control in sandy soils with low water table.

6. Analysis of tree distribution and millet growth on farmers fields.

Biodiversity Survey at Hamdallaye

Two distinct types of vegetation were observed in the watershed: (a) a *Combretum micranthum* community (tiger bush) on laterite plateaus; and (b) a shrub savanna of *Guiera senegalensis* on sandy soils of valley toposequences.

The plateau vegetation consists of a series of thickets of variable size, with *Combretum microcanthus* and *Guiera senegalensis* as dominant species, separated by bare areas with small pockets of herbaceous species (*C. glutinosum*, *Commiphora africana*, *Boscia senegalensis*, *B. augustifolia*, etc.) which usually grow on small mounds of sand. Three strata are identified:

1. An open, herbaceous strata within bare areas (height up to 40 cm).

2. A strata of shrubs with an open nature in bare areas, and more dense growth at the fringe of the thickets (0.5 - 2.5 m).

3. A strata of trees at the center of the thicket (up to 10 m).

The valley toposequence is severely affected by cultivation and soil erosion. The vegetation consists of three strata:

1. A herbaceous strata dominated by grasses.

2. A strata of scattered shrubs (*G. senegalensis*), at least 80 cm in height.

3. A strata of a few trees higher than 10 m.

There were 119 species identified in the watershed. Annual species are predominant (65%). Almost 30 species are frequently used by the local population as forage or

for human consumption, for construction, to stabilize soils from wind erosion, or as medicine.

Soil Variability and Acacia albida

A strong association was found on a young tree nursery between the growth of Acacia albida and pre-existing soil chemical and physical properties. Conclusions are that the A. albida effect reported in the literature may be due, in part, to soil spatial variability that may be caused by the presence of old termite mounds, soil erosive surfaces and soil microtopographic differences. This research will lead to the development of more efficient seedling placement strategies for extension foresters, that will replace the current method of planting A. albida on a grid pattern.

Natural Revegetation of Laterite Plateau

Soil structures (digettes) were implemented on a laterite plateau to take advantage of natural conditions as proposed within the general theories of tiger-bush formation within the Sahel. Digettes were constructed in bare areas between thickets, and on an adjacent site only in the bare areas found laterally between thickets. The objective was to observe the effect of the structures on pre-existing vegetation and to better take advantage of the water-harvesting quality of the plateau surface. Preliminary results indicate that water flow across the plateau was effectively controlled for both systems. Some natural growth occurred within the digettes during the first year. This work will need to be monitored for three to four years to obtain a concise estimate of the effectiveness of this practice on plateau surfaces.

Gully Control

This activity involves the installation of digettes and laterite rock bunds to control water flow into and through a gully arising from the surface of the laterite plateau and extending into farmers fields. Water flow was slowed down as compared to a control gully, and water infiltration enhanced on the highly eroded surfaces surrounding the gully. Some natural vegetation regeneration occurred in the first year. This work will need to be monitored for three to four years to ascertain the long-term effect on gully development and rejuvenation. The high cost of transport of laterite rocks is a constraint for this practice. the use of bales of organic material (millet residues, shrub branches) seems to be a more cost-effective alternative.

Windbreaks for Wind Erosion

Windbreaks were designed using five species: Ziziphus mauritiania and Bahunia refuscens, which are used for fodder and food production; Andropogon gayanus which is a grass used for house and mat construction; and Guiera senegalensis and Piliostigma reticulatum, which are the dominant shrub species found in the plateau and valley geomorphic region of Western Niger. G. senegalensis or P. reticulatum were included due to their dominance of the local ecology, sporadic use by farmers for surface mulches, and reduced palatability to livestock. The windbreaks were planned along north-south oriented field boundaries for purposes of observation and demonstration. A nursery was started in the spring of 1990. Farmers fields were surveyed at the Hamdallaye watershed for emplacement, but budget problems prevented implementation in 1990.

Tree Distribution and Millet Growth

This activity consisted of a survey of 520 sites in 12 fields within the Hamdallaye watershed, relating micro-topographic relief and the presence of erosional surfaces to millet growth and tree distribution. Micro-high areas were highly correlated with the presence of local trees (mostly Guiera senegalensis and Piliostigma reticulatum. Micro-highs were also highly associated with wind erosional surfaces (Gangani kirey), indicating the effect of small trees (< 2m) on entrapping wind-eroded materials that arise from adjacent soils. The presence of micro-highs also resulted in a significant increase in millet yield over areas of farmers fields without micro-highs present. This work will help the design of agroforestry research related to windbreak development and surface mulch utilization, as well as provide insights into the causes and effects of soil spatial variability.

Project Title: Evaluation of indigenous soil and crop management technologies. TAMU-405.

Constraints Addressed: Inadequate resource information

Project Leaders by Institution:

A. Manu	TAMU/TAES
M. Gandah	INRAN (Niger)
F. Bedari	INRAN (Niger)

Research Collaborators by Institution:

M. Ouattara	INRAN (Niger)

A. S. R. Juo TAMU/TAES
S. Geiger TAMU/TAES
R. Puentes TAMU/TAES
L. Wilding TAMU/TAES
E. Taylor-Powell Consultant

PROJECT PROGRESS REPORT

Summary of Research

Neglect of indigenous knowledge has led to failure of many agricultural development projects because interventions proposed often times have not fit in with local perceptions. Project TAMU-405 targeted a small agricultural watershed near Hamdallaye (see projects TAMU-402 and TAMU-406 for further details). A survey on land tenure, indigenous soil and crop management technologies, and farmers' perception of agricultural problems was completed in 1990.

The land tenure system is based on the settlement history of the region. Zarma pioneers originally moved into areas and gained rights to the land they cleared as the first cultivators. Under Zarma culture, land passes from father to sons through a patrilineal inheritance system. Today, all land in the watershed is claimed by families of the original settlers.

A millet-cowpea intercropping system characterizes the watershed's land use. The overall production objective is to provide subsistence food grains and to market a portion of the production to meet cash needs. Most labor is manual.

Nearly three-fourth of the households own livestock, principally mixes of goats, sheep, and cattle. Cattle is usually entrusted to Peul herders. Although in a few cases it is managed year-round in the watershed, most of the time cattle is outside the watershed during the growing season. It is brought back to the farmer's fields after harvest for crop residue grazing and manuring.

Improved millet and cowpea varieties have been available in the region since 1982. Most farmers, however, use local varieties: 83% of farmers use local millets, and 93% of them use local cowpeas varieties. Main disadvantages perceived with improved varieties are:

1. Because they ripen earlier, they are more susceptible to bird and insect attacks;

2. Improved varieties must be weeded sooner after planting and there are conflicts with other labor priorities; and

3. Improved varieties only produce well if fertilizers are used and all management recommendations are followed.

Farmers consider rainfall the principal determinant of crop production. In good rainfall years, production levels are adequate by farmers' standards regardless of land quality. But under unfavorable rainfall conditions, farmers stress the interaction of poor rainfall and soil fertility in depressing production. Rainfall patterns are considered particularly problematic because the "land is old and tired," a common phrase among farmers.

Agricultural practices have changed in response to perceived environmental circumstances affecting the region. Farmers speak of a 7-8 month dry season in the past when they could count on four months of rain. Today they can depend on only three good months of rain. Most have abandoned samno, late season millet, because of the shortened rainy season and insufficient soil fertility. Many farmers plant dry, mix varieties, and follow various strategies to minimize risks.

Animal manure, and secondly chemical fertilizer, are recognized as primary means for improving productivity levels. Farmers report limited access to animal manure given the decreased number of permanent and transhuman cattle in the region. Fertilizers, on the other hand, are not always readily available and high cost limits its usage.

Land degradation is associated to loss of vegetation and increase in wind. Farmers attribute loss of vegetation to general climatic changes, the severe drought ending in 1974, and increased cultivation. They speak of a reduction of vegetative cover and changes in species composition. Water erosion was seldom mentioned as an agricultural problem. Wind erosion emerged as more of a concern among interviewed farmers. Wind erosion is ubiquitous, and affect all farmers; water erosion, in contrast, is more site-specific, depending on location and slope of fields.

In summary, farmers in the watershed possess interesting ecological knowledge about their physical environment. They have developed their own classifications for soils, erosion surfaces, and crop fields according to years under cultivation and fallow. They show resiliency and

adaptability in responding to agroecological changes, and they continue to experiment with various risk-avoidance soil and crop management strategies, soil restoration techniques, and wind erosion control practices.

The survey conducted at Hamdallaye will be helpful to delineate a strategy of interventions for a sustainable increase in productivity. It did not capture, however, the whole diversity and complexity of households economies and farmers decision-making determinants. Information being collected by IFPRI and ICRISAT in case studies of Sahelian villages will help in filling the voids in our current understanding of peasant land use systems.

Project Title: Land resources characterization and evaluation in the semi-arid tropics. TAMU-406.

Constraints Addressed: Inadequate resource information
Landscape restrictions

Project Leaders by Institution:

L. Wilding	TAMU/TAES
A. S. R. Juo	TAMU/TAES

Research Collaborators by Institution:

M. Ouattara	INRAN (Niger)
M. Bachir	INRAN (Niger)
M. Salou	INRAN (Niger)
P. Sankara	Peanut CRSP (Burkina Faso)
A. Manu	TAMU/TAES
S. Geiger	TAMU/TAES
R. Puentes	TAMU/TAES
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A. Pfordresher	TAMU/TAES
L. R. Drees	TAMU/TAES

PROJECT PROGRESS REPORT

Summary of Research

Most soil resources in semiarid Africa are highly fragile, droughty, and commonly exhibit chemical toxicities or nutrient deficiencies. Soil constraints pose a major limitation to agricultural development. A knowledge in soil resources is fundamental for selection of target sites for purposes of research and demonstration, interpretation of research results, and technology transfer.

Activities for project TAMU-406 in 1990 included:

1. Baseline soil resource conditions for major soils and target research sites.

2. Baseline soil resource studies for small agricultural watersheds.

3. Dynamics of soil moisture movement and chemical characteristics of soil toposequences in Niger.

4. Development of micromorphological procedures to quantify changes in soil porosity and hydrological behavior in Vertisols.

Baseline soil resource conditions on target research sites

As a result of initial deliberations among TropSoils and Peanut CRSP Project Leaders at TAMU, it was decided that these two CRSPs should couple their expertise to evaluate soil conditions in Burkina Faso and Niger where peanut breeding trials are underway under the sponsorship of the Peanut CRSP. The first phase of this work was to evaluate target research sites at Tenkodogo, Gampela, Kombissiri, and Bobo-Dioulasso, in Burkina Faso, and in Maradi, in Niger. A second phase, including activities in Mali and Senegal is under consideration for 1992. This is the first known joint venture between these two CRSPs, but hopefully, it will provide the inertia to foster future linkages and coordination of research efforts.

The work was conducted by Dr. L. Wilding from TAMU (College Station), Dr. A. Manu, TropSoils-TAMU research team leader in Niger, and Dr. P. Sankara (plant pathologist, Peanut CRSP in-country coordinator in Burkina Faso). The team covered over 2600 km in Burkina Faso, from the driest region at Gampela (760 mm) to the most humid region at Bobo (1400 mm). Detailed logs on soil descriptions for all sites were prepared. Characterization analysis were conducted at TAMU characterization laboratory, at College Station.

Soils observed in Burkina Faso were mostly loamy to clayey Alfisols and Ultisols. They contain more weatherable minerals, are finer in texture, have higher base status, and have greater agricultural potential than similar sandy soils in Niger. Those in Niger were very sandy, acid Alfisols or Entisols of eolian sand origin. Burkina Faso peanut soils are deep, well drained, sandy to clayey in texture, medium to very strongly acid in

reaction, and contain low activity clay systems with low nutrient retention and moderate reserves.

Based on soil observation and characterization, major constraints to crop production on these soils are as follows:

- highly variable and unpredictable precipitation,
- degradation of weakly structured soil,
- soil crusting and sealing,
- wind and water erosion on bare surfaces,
- spatial crop responses,
- soil infertility,
- low organic matter content,
- low soil water retention and drought susceptibility, and
- high P-fixation and unavailability (at Bobo-Dioulasso, especially)

Baseline soil resource studies for small agricultural watersheds

This activity was part of the comprehensive baseline studies conducted at Hamdallaye, Niger. The dominant geomorphological feature of the watershed is a laterite-capped plateau located at the northern end of the study area. A toposequence of soils commences at the edge of the plateau and extends for approximately 1.5 km to the valley floor. The general slope is broken by two laterite formations which are exposed on the western side, but buried on the eastern side of the watershed. Slope decreases as the laterite formations are approached, and then increases at the downslope side of each outcrop.

Hydrology is dependent on geomorphology. There is a large concentration of incipient gullies occurring on the steep slopes directly below the plateau. Incipient gullies also occur on soil below the second laterite outcrop. As gullies approach soils with gentle slopes, water flow velocity decreases and depositional fans are formed.

Seven soil series were identified. Soils used by farmers for food crop production are sandy to loamy sand in texture. Their poor fertility is reflected in low organic matter contents (<0.37%), low CEC's (<2.55 cmol (+)/kg) and low levels of available P (<3.7 ppm).

Wind and water erosion are major constraints to productivity. Wind erosion is evident throughout the watershed. The degraded nature of the natural vegetation

results in soil surfaces highly susceptible to wind erosion during the dry season. Water erosion is evident in the form of gully, rill and sheet eroded surfaces, as well as the formation of sand outwash fans and isolated land masses that are severely eroded (gangani). Sheet erosion is evident on productive fields; it needs to be quantified in terms of loss of soil productivity to ascertain the need for erosion control interventions. Soil crusting is widespread; it affects rainfall infiltration and inhibits seedling emergence.

Dynamics of soil moisture movement and chemical characteristics of soil toposequences in Niger

Relationship between landscape position and soil characteristics such as moisture regime, phosphorus fixing capacity, and acidity were investigated on two toposequences of western Niger. The sites have 550 mm (Hamdallaye) and 750 mm (Malgorou) of annual rainfall. At the Hamdallaye toposequence, soils are formed on deep eolian mantle, are sandy and were classified as Ustipsamments and Kandiustalfs. At the Malgorou toposequence, soils are generally formed on Continental Terminal residuum; they are loamy in texture, shallow, and gravelly at depth. Soils at Malgorou were classified at Kandiustalfs and Kanhaplustalfs.

Characteristics common to soils of both toposequences are low organic matter, low ECEC and a pH moderately to strongly acid. The standard P requirement (SPR) of soils was very low at Hamdallaye and low at Malgorou. No trend in P sorption was observed along the toposequence at Hamdallaye; at Malgorou, an increase in P sorption was observed down the slope in a segment of the toposequence. The P sorption increased about 2.5 fold from surface to the upper sub-horizons at both toposequences. SPR values appear to be highly correlated with soil characteristics at the two sites. There was no simple relationship between soil moisture availability and topographic position at either toposequences; main factors controlling moisture availability were surface texture, crusting and evapotranspiration. Soil Taxonomy placements of soil moisture regime are ustic at Hamdallaye and marginally ustic to aridic at Malgorou.

Changes in porosity and pedality were studied at different magnifications, with the aid of microfabric techniques coupled with image analysis. Undisturbed samples were taken at two depths (0-16 and 16-32 cm) using 16x9x5 cm Kubiena tins. Samples were dried through acetone replacement and impregnated with a mixture of polyester, acetone, and a fluorescence dye (to facilitate

pore recognition). Hardening was promoted with gamma radiation. Horizontal and vertical polished blocks and thin sections were illuminated with UV lamps and 1:1 scale pictures were taken with high contrast film. Natural clods were studied with the stereoscopic microscope. Thin sections were analyzed with the petrographic microscope. Porosity from thin sections and high contrast negatives was quantified using image analysis techniques.

The analysis of variance components showed the variability at the Kubiena sample and thin section levels for several porosity-related features (% of porosity, pore area, shape, orientation). A sampling scheme with four Kubienas and four sections from each Kubiena was adequate for the simultaneous analysis of several porosity properties. Image analysis of high-contrast negatives of polished blocks saved time and labor. Pore identification was facilitated with a UV dye included in the impregnating mixture. A high correlation (r=0.8) was observed between porosity measurements by fully automated and manual image analysis systems.

Significant changes in porosity and pedality occurred when land use shifted from continuous cropping to pastures. Macropore volume doubled from 7% to 14%. Pore size distribution shifted towards larger pores. The strong horizontal preferred orientation of pores under continuous cropping evolved into a system with randomly oriented pores under pastures. Surface horizons recovered their self-mulching properties, compacted layers disappeared, and subsurface horizons developed stronger pedality. As a consequence, infiltration rates increased significantly.

Project Title: Process of soil degradation/ rejuvenation under different land use systems. CU-2 and CU-3.

Constraints Addressed: Soil structure
Crusting

Project Leaders by Institution:

Philippe Baveye	CU
Murray McBride	CU
Host Country Scientists to be Identified	

Research Collaborators by Institution:

Charles Bielders	CU
Kirsten Verburg	CU
Eugenio Marcado-Martinez	CU

Host Country Scientists to be Identified

PROJECT PROGRESS REPORT

Summary of Research

The project is still largely in its initiation phase. Charles Bielders and Eugeno Marcado-Martinez have been funded by TropSoils for the whole of 1990, while Kirsten Verburg joined the project only in the Summer. All three students have concentrated their efforts on defining precisely the scope of their research and on selecting a site where they will be able to carry out their field experiments.

On both of these fronts, satisfactory progress has been made. In late June 1990, Eugenio Marcado-Martinez went to Costa Rica, along with a group of scientists from Cornell to establish contacts with host country scientists and obtain detailed information on a number of researchable topics. As a result of this trip and of further contacts between Dr. McBride and Dr. Bornemiza of the University of Costa Rica, Eugenio Marcado-Martinez has decided to focus his research on the chemical aspects of aggregate stability in well-aggregated utisols and alfisols of Costa Rica. Preliminary research on model kaolinite systems has been started in mid-Fall.

Similarly, a trip by Charles Bielders to Lome (Togo) during the Summer of 1990 has made it possible to agree with Togolese scientists on a possible collaboration between these two institutions and Cornell. Charles Bielders will concentrate his efforts on the process leading to the promotion of a surface crust in oxisols of the Southern part of Togo ("Terres de Barre"). He will also investigate the effect of this surface crust on the infiltration pattern in these soils. During the Fall, he took care of his last graduate courses and researched the literature related to crusting processes.

Kirsten Verburg was immersed in course work during the Fall and did not make significant progress yet toward defining her research topic.

Project Title: Extent, cause, and control of pronounced plant growth variability over short distances. TAMU-407.

Constraints Addressed: Landscape restrictions

Project Leaders by Institution:

L. R. Hossner	TAMU/TAES
L. Wilding	TAMU/TAES

Research Collaborators by Institution:

M. Issaka	INRAN (Niger)
Z. Kouyate	IER (Mali)
M. Doumbia	IER (Mali)
A. S. R. Juo	TAMU/TAES
A. Manu	TAMU/TAES
A. Onken	TAMU/TAES
A. Pfordresher	TAMU/TAES
R. Maggio	TAMU/TAES

PROJECT PROGRESS REPORT

Summary of Research

Microvariability has been defined as the local and often recurrent variation at the scale of a single field or smaller, which is either permanent or at least persists through several cropping cycles. The aerial extent, distribution, and causes of short-distance crop variability in millet and sorghum fields in Niger and Mali have been reported in previous progress reports.

Additional flights using IR-Video imagery techniques have been obtained for millet fields in Niger. These aerial surveys will allow to quantify differences in crop establishment of two seasons with different total rainfall. Changes in location of non-productive areas will be also analyzed. Images will be processed in 1991.

Farmers' perception of soil variability at the field level was surveyed at Hamdallaye, in Niger. Farmers classify soils according to color, soil texture, and degradation status. Within-field variability is well recognized: farmers try to profit from favorable micro-environments. For instance, in millet-production areas, sorghum, sorrel, gumbo and maize are planted in small depressions (heavier-textured soils and more favorable soil moisture), in areas where animals have been kraaled or tethered, in bonfire locations, and in grain pounding sites where litter has accumulated. Higher productivity within fields is also associated to ants (n'kondo) and termite (tcharra) colonies.

The current focus of Project TAMU-407 is the development of remediation strategies which are appropriate to small Sahelian farmers. As the problem is site specific, current efforts target the problem of P deficiency and Al toxicity affecting sorghum growth and yield in sandy

soils in Mali. Research has been initiated in Grossarenic and Plinthic Paleustalfs at the Cinzana Agronomic Research Station. The control strategy is based on using locally-available soil amendments and selected sorghum genotypes.

A common feature of research plots in 1990 was that the percentage of planting hills displaying symptoms of poor early growth was very low. Percentages of 15% were common (compared to 60% in 1986 and 1987). The fact that the research plots are located in a three-year old fallow field (abandoned plot due to soil problems) may explain the mildness of the problem in 1990.

Selected sorghum genotypes (Babadia Fara, CSM 63, Malisor 84-7, and AT x 632 x Dorado) were tested in a factorial experiment with 0,15, and 45 kg ha^{-1} of both N and P_2O_5. Each genotype established a very good crop stand and the effects of N and P levels were apparent. As expected, combining the two nutrients enhanced growth compared to applying either nutrient alone.

Different rates of corrective inputs--manure, Tilemsi rock phosphate (RP), and Diamou lime--were combined to different levels of mineral supplements (N and P) in three factorial experiments, planting Malisor 84-5, which is sensitive to the soil problem. In the manure experiment, sorghum growth with increasing manure rates (0, 2.5, 5, 10, 15, and 20 tons ha^{-1}). No treatment effects were observed in both Tilemsi RP (0, 30, 50, 75, 100, and 150 kg P ha^{-1}) and Diamou lime (0, 1, 2, 3, and 4x lime requirement) experiments.

These experiments will be replicated in 1991 for a second set of data.

Project Title: Development and evaluation of soil and water management and conservation practices for rainfed agriculture in soils in sub-Saharan Africa. TAMU-402.

Constraints Addressed: Landscape restrictions
Production-demand pressure
Land-clearing pressure
Climatic variability

Project Leaders by Institution:

A. Manu	TAMU/TAES
A. S. R. Juo	TAMU/TAES
M. Gandah	INRAN (Niger)

Research Collaborators by Institution:

M. Ouattara	INRAN (Niger)
F. Bedari	INRAN (Niger)
A. Sow	IER (Mali)
S. Geiger	TAMU/TAES
R. Puentes	TAMU/TAES
L. Wilding	TAMU/TAES
C. Coulombe	TAMU/TAES
J. Heil	TAMU/TAES
T. Thurow	TAMU/TAES
C. Wendt	TAMU/TAES
E. Taylor-Powell	Consultant

PROJECT PROGRESS REPORT

Summary of Research

An integrated approach has been adopted to manage small agricultural watersheds in western Niger. A 495 ha watershed near Hamdallaye (approximately 35 km ENE of Niamey, Niger) has been selected; baseline studies conducted during 1990 included soils and geomorphology (reported under Project TAMU-406), vegetation (reported under Project TAMU-404), and indigenous soil and crop management technologies (reported under Project TAMU-405). This report summarizes the integration of baseline studies into a geographic information system (GIS) and the delineation of "land use management" units (LMUs) for purposes of research and demonstration.

The watershed is located in the plateau-sand-valley system, which is extensive in this region of Niger and throughout the Sahel. There are 41 families from four villages with activities within the watershed. Agricultural lands are used for millet/cowpea intercropping. Wind and water erosion are major constraints to productivity. Wind erosion evidences are ubiquitous throughout the watershed. Water erosion evidences are localized in the form of gullies along the toposequence, rill and sheet eroded surfaces within farm fields, and the occurrence of sand outwash fans and distinct areas with exposed B_t horizons.

The information for the topographic, soil/ geomorphology, indigenous knowledge, and vegetation surveys was integrated with the aid of a GIS. Five major land management units (LMUs) were delineated based on perceived management requirements and potential. LMUs are defined as recognizable recurring subsystems within watersheds that have well defined sets of attributes, characteristic locations and aerial distribution. Each LMU requires a different land use and management strategy

for sustainable production. The LMU concept facilitates the development, adoption and transfer of successful watershed management technologies throughout similar watersheds.

LMU-I: Tondobon

It occupies the highest relief position: the laterite plateau. Dominant soils include the shallow to laterite, gravelly sandy loam soils of the "Plateau" series, and the stony and severely eroded soils of the "Tondo Kakasia" series. Low water acceptance generates high volumes of runoff that affect LMUs down along the toposequence. Vegetation is a Combretum micranthum community (tiger bush), and the unit is viewed by farmers as a commons area providing fuel, medicines and grazing for livestock.

LMU-II: Tondo Kakasia

The unit comprises steep slopes and severely eroded, crusted soils with exposed B_t horizons. The area is used by farmers for extracting medicinal herbs and exploitation of Andropogon gayanus for construction purposes.

LMU-III: Fondu

This is the most important LMU from the agricultural point of view, comprising 76% of the watershed. Topography is gently sloping, with deep, sandy, low fertility soils (Dantiando, Hamdallaye, Bokotchili and Falanke soil series). Low moisture retention capacity, low nutrient availability and erosion hazard are main constraints to crop production. Soils are intercropped with millet and cowpeas, with three-to-five-year fallow periods. The natural vegetation is a shrub savanna of Guiera senegalensis.

LMU-IV: Gangani Kirey

It comprises shallow, crusted soils, with exposed B_t horizons (lithic phases of the Gangani Kirey and Hamdallaye soil series). Crops are grown only in areas where a 10-20 cm layer of sand overlays the crusted soil. Andropogon gayanus and Aristida sieberiana are widespread, and used by farmers as construction material.

LMU-V: Gorou

This LMU includes gullied areas and sand outwash systems. Most gullies originate at the base of the scarp adjacent

to the laterite plateau, or at secondary laterite outcrops. They are generally shallow (<1 m depth) and where slope decreases they form an outwash fan that spread through productive fields.

Specific land use and soil/crop management interventions for each of these LMUs are being discussed with INRAN collaborators and are part of the 1991 work plan.

Project Title: Soil characterization and classification. NC-7.

Constraints Addressed: Landscape restrictions
Inadequate resource information
Production demand pressure

Project Leader by Institution:

S. W. Buol NCSU

Research Collaborators by Institution:

M. P. F. Fontes
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S. B. Weed
J. W. Hooper
H. Eswaran
K. Matungulu
B. Johnson
I. Lepsch

PROJECT PROGRESS REPORT

Summary of Research

The soil organic matter content of tropical soils is often as high as that of temperate soils. Little is known about the controls and losses of soil organic matter content in variable change soils. Increase in knowledge will help in the management of the fertility of these soils.

Arrangements were made with the Lincoln Laboratory of the Soil Conservation Service to obtain their tropical pedon data base. A total of 182 pedons with sufficient data for classification at the family level of soil taxonomy can be used to evaluate the determinants of SOM temperate, moisture, texture and mineralogy, in comparison with the larger (486 pedon) temperate region data base. These data bases were successfully used to estimate the effects of increasing soil temperature projected as a result of global warming on soil organic

matter contents. We found that a projected 3°F increase in mean annual soil temperature represents an average loss of 576 g C m^{-2} to a 30 cm depth in the temperate zone. Soils of differing pH, textures, and mineralogies have been collected from locations in the humid and seasonal tropics in Peru, Brazil and Indonesia, in addition to a Mollisol from Colorado.

Laboratory incubations designed to promote maximum organic matter decomposition are being conducted with samples from Brazil, Peru, Indonesia and the U.S. All samples are from undisturbed sites. Air-dried samples were rewetted to field capacity and kept continuously moist at a temperature of 35 ± 2°C in an incubation chamber, and measured periodically for total C. Preliminary results after 16 weeks of incubation confirm that SOM decomposition is affected by clay mineralogy. Smectite mineralogical families of U.S. Mollisols, where the Century model is based, produce faster decomposition rates that kaolinitic Ultisols, oxidic Oxisols and allophanic Andisols, in spite of initially higher SOM content in the latter two mineralogies. Although clay content varies and undoubtedly affects decomposition rates, it is apparent that mineralogy exerts a major influence under constant temperature and moisture.

We then subjected the buried A horizon of an Oxisol with high SOM content to nutrient additions and crushing to determine if the low decomposition rates could be due to low nutrient availability to microorganisms, physical protection or chemical recalcitrance. Additions of nutrients by liming and fertilization did not increase SOM decomposition, neither did crushing the limed and fertilized soils. Consequently, we hypothesize that chemical recalcitrance may be the main process responsible for low initial decomposition rates in this oxidic soil. In addition to the laboratory work, field trips were made to Ranomafana, Madagascar, Central and Southern Africa, and the Chapare Region of Bolivia to make preliminary soil surveys for future studies on land-use in the regions.

B. Sustainable Agriculture Production

Project Title: Diagnosing and correcting soil acidity and infertility. UH-1.

Constraints Addressed: Soil acidity

Project Leader by Institution:

Lalit Arya UH

Research Collaborators by Institution:

Nguyen Hue	UH
I. P. G. Wijaja-Adhi	CSAR (Indonesia)
M. Oka	CRIFC (Indonesia)
B. F. Rusman	Padjajaran U (Indonesia)
Russell Yost	UH

PROJECT PROGRESS REPORT

Summary of Research

For the resource-poor farmers, lime is expensive and difficult to incorporate into the subsoil where it is needed to detoxify aluminum. Without lime, only a limited number of acid tolerant crops of low nutritional value can be grown. The precise cost-effectiveness of lime application is not known because: 1) the residual effect and therefore the amortization of costs over several years cannot be quantified for sound economic analysis; 2) the optimum depth of lime incorporations which depends on amount and distributions of rainfall cannot yet be readily determined; and 3) the role of organic matter as a substitute for lime is not known.

These knowledge gaps prevent the large knowledge base on liming from being used to assess the economic feasibility of liming and fertilizer use. Addressing these issues, this project seeks to: 1) measure the long-term residual effect of lime, phosphorus, and organic matter on crop performance and the economics of production; 2) identify the optimum depth of lime and organic matter incorporation with different water retention characteristics under dry and wet season farming; and 3) collect lime-leaching data to develop transport equations that will predict movement of lime in the rhizosphere.

Results from this study indicate that deep liming has a significant positive effect on maize production in Sitiung soils. Deep liming promotes deep rooting and makes available a larger volume of soil for water and nutrient absorption. As a result, plants continue to function normally even during rainless periods of several days. Both water and nutrient use efficiencies are increased. A shallow rooted plant, on the other hand, cannot utilize water and nutrients stored in the subsoil. The effect is not temporary. Since movement of lime in the soil is negligible, the residual effect may last several years. Although deep liming is a labor-intensive operation, it appears to be a worthwhile investment.

Owing to its relative immobility and long residual effect, lime may be looked upon as a capital cost by agricultural development agencies. Lime acts as an inexpensive substitute for an irrigation system. this research demonstrates that the main benefit of liming is to increase water availability to crops. Deep incorporation of lime results not only in yield increases but contributes to yield stability by enabling a crop to weather drought.

Project Title: Continuous cropping fertility and tillage management. NC-1.

Constraints Addressed: Soil acidity
Nutrient deficiencies and losses
Soil physical limitations
Weeds

Project Leader by Institution:

J. C. Alegre	NCSU

Research Collaborators by Institution:

T. J. Smyth	NCSU
R. J. Melgar	INTA (Argentina)
M. Cravo	EMBRAPA (Manaus)
F. R. Cox	NCSU
E. Uribe	Caja Agraria (Colombia)
P. A. Sanchez	NCSU
J. Davelouis	NCSU
D. K. Cassel	NCSU
M. Galvez	INIAA (Yurimaguas, Peru)
W. Guillen	INIAA (Yurimaguas, Peru)

PROJECT PROGRESS REPORT

Summary of Research

The long-term sustainability of intensively managed crop rotations involving nutrient requiring crops such as corn, soybeans and other green legumes is amply demonstrated by the tow long-term experiments: 37 consecutive crop harvests during 17 years of continuous cultivation in a sandy Ultisol of Yurimaguas, Peru, and 17 consecutive crop harvests during nine years of continuous cultivation in a clayey Oxisol of Manaus. Crop yields have been maintained at adequate levels and soil properties have improved rather than deteriorated. Without adequate management, however, yields drop to zero and soil properties deteriorate rapidly.

Advances were made in the efficiency of nitrogen, phosphorus and potassium fertilization in corn-based systems. Studies conducted in Manaus show that native soil nitrogen is initially higher in Entisols of "varzeas" or alluvial plans than in the upland Oxisols. Management practices to alleviate subsoil aluminum toxicity allow corn roots to penetrate deeper into the Oxisol, making use of available subsoil nitrogen, which results in increasing yields and fertilizer recovery.

Eleven crops in a corn-cowpea rotation in clayey Oxisols of Manaus with high phosphorus fixation capacity show that the phosphorus fertilizer needs to be much smaller than commonly thought: banded applicator of 22 kg P/ha per corn crop and 44 kg P/ha per cowpea crop, under manual tillage practices used in the region. Critical soil test and tissue phosphorus levels were established for corn, cowpea and peanut for clayey Oxisols, including calcium requirement for peanuts.

Efficiency in the use of potassium fertilizers were also dramatically increased in corn-soybean rotation, decreasing the recommended fertilizer rates by half. A six-crop experiment conducted at Yurimaguas on a sand and loamy Ultisols show that with appropriate timing and crop residue return, a single annual potassium application of 60 to 90 kg K/ha applied to the corn crop is sufficient to meet the potassium needs of both crops. Previous recommendations were on the order of 160 to 200 kg K/ha per year.

Once chemical problems are solved, physical properties begin to limit production. Switching to minimum tillage has yet to product significant yield differences after five crops but reduced runoff losses by half, in an environment where 50 percent of the rainfall events are highly erosive. Subsoiling conventionally tilled fields increased corn grain yields by 30 percent, indicating the presence of compacted layers due to management.

Growing cover crops instead of a third annual crop in corn-grain legume rotations way provide a ground cover during the rainiest part of the year, smother weeds, fix nitrogen and complex aluminum. Advances have been made in some of these aspects. High quality green manures that have low lignin and polyphenolic contents, such as kudzu and rice straw, ameliorated soil acidity temporarily which low quality ones like Inga edulis exacerbated soil acidity.

The effect of Centrosema macrocarpum to control weeds were disappointing. A four-month green manure crop did

not control weeds in a subsequent corn crop as well as chemical herbicides. A minimum of six to eight months of growth in order to control weeds more effectively than herbicide applications.

Project Title: Low input cropping systems for acid soils of the humid tropics. NC-2.

Constraints Addressed: Soil acidity
Nutrient deficiencies and losses

Project Leader by Institution:

P. A. Sanchez	NCSU

Research Collaborators by Institution:

T. J. Smyth	NCSU
J. C. Alegre	NCSU
C. A. Palm	NCSU
W. Bustamante	INIAA (Peru)
A. Racchumi	INIAA (Peru)
W. Guillen	INIAA (Peru)

PROJECT PROGRESS REPORT

Summary of Research

In the central low-input experiment, the second cropping period after one or more years of kudzu fallow is definitely shorter than the first. Instead of producing seven crops in three years without external nutrient inputs, only three acceptable crops can be produced int he second go around. Weed pressure becomes progressively worse and fertility depletion continues, probably due to net phosphorus export via grain removal. Attempting to prolong the initial cropping period with unrealistically high levels of herbicide application did not improve the

A host of new cowpea varieties showed both Al-tolerance and high yield potential. Some promising sweet potato varieties have been identified.

A 12-crop potassium dynamics experiment show that returning crop residues practically eliminate the need for K fertilization in this system.

A chronological low-input nutrient depletion study shows that with appropriate residue and weed management, via cover crops, eight crops of rice and cowpea were produced in three years without a significant response to nitrogen on phosphorus fertilization.

Project Title: Legume based pastures for the humid tropics. NC-3.

Constraints Addressed: Soil acidity
Nutrient deficiency and losses
Soil physical limitations
Water stress

Project Leader by Institution:

P. A. Sanchez	NCSU

Research Collaborators by Institution:

Miguel A. Ara	CIAT (Colombia)
Deysi Lara	INIAA (Yurimaguas, Peru)
Carlos Castilla	NCSU

PROJECT PROGRESS REPORT

Summary of Research

A pure legume pasture of Centrosema pubescens 438 continues to produce the highest and most consistent levels of animal production after eight years of grazing. A mixture of creeping relatively unpalatable grass (Brachiaria humidicola) and legume (Desmodium ovalifolium) has also produced sustainable results. Other grass-legume mixture, Brachiaria decumbens-Desmodium ovalifolium have proved to be unsustainable or difficult to manage at Yurimaguas.

Under a drier climate (1500 mm rainfall) and clayied Ultisols at Pucallpa, Peru, the mixture of Brachiaria decumbens with Desmodium Ovalifolium provided as much nitrogen to the pasture biomass as an application of 300 kg N/ha/yr of urea to the pure grass. Animal intake also suggests the same relationship. Over a 30-month grazing

season, the inclusion of the legume provided about half the nitrogen consumed by the animals, the rest coming from recycling of the grass components. Only about one-third of the legume contribution was via direct intake of the legume and the rest through the enhancement of the nitrogen content of the grass. Of the remaining two-thirds, only about 10 percent was due to N transfer through legume litterfall to the grass and the remainder is assumed to be due to recycling of legume-N via animal excreta and root turnover.

The Century model for soil organic matter dynamics was modified for Yurimaguas conditions using the long-term experiment data. Simulation predicts that roots are the major driving force in the maintenance of topsoil organic carbon. Sustainable pastures have increased topsoil organic matter contents in Yurimaguas.

In a study on the causes of pasture degradation, it was found that overgrazing causes a crash in the endogenic earthworm population, resulting in increased bulk density. Under adequate grazing pressures, earthworms may ameliorate compaction by cattle trampling and help maintain bulk density at acceptable level.

Three ecotypes of Desmodium ovalifolium were found to be more palatable than CIAT 350 and several accession s of Centrosema pubescens and Centrosema acutifolium show agronomic promise at Yurimaguas. An example of farmer adoption of improved pasture technologies is ongoing in the community of Schucshuyacu.

Project Title: Nutrient balance for cropping systems based on legume green manures in Oxisols and Ultisols. CU-111.

Constraints Addressed: Soil acidity
N-management

Project Leaders by Institution:

Michael Cahn	CU
D. R. Bouldin	CU
Manoil da Silva Cravo	Centro de Pesquisa Agroflorista du Amazonia CPAA, EMBRAPA

PROJECT PROGRESS REPORT

Summary of Research

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 a Oxisol of the humid tropics, where subsoils acidity inhibits deep rooting.

A 1.3 year split-plot field experiment was conducted on a clayey oxisol (Typic Acrudox), near Manaus, Brazil to: 1) measure the leaching of NO_3, Ca, Mg, and K and the acidification of an oxisol under cropping sequences utilizing urea and legume-green manure sources of N, and 2) measure the effects of soil acidification on maize and legume yields. Main plots received two levels of lime (0 to 4 t/ha $CaCO_3$) and a blanket application of K (80 kg/ha). Sub-plots were cropped with 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 of 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 fraction accumulated in the subsoil during 120 days. Also, a significant portion of the nitrate leached beyond 1.2 m during the experimental period. Nitrate was sorbed onto the solid phase; sorption increased with depth and it had an important influence on the rate of leaching of NO_3 and cations. Calcium and magnesium leached from the plow layer; some accumulated in the subosil, and some was lost from the soils 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: 1) grain yields of unlimed plots, receiving urea, decreased by about 50 percent between the first and third maize crops; and 2) the effect of lime on the weight of legume dry matter increased with time.

Cation leaching reduced subsoil acidity, but not sufficiently for roots to penetrate deeply. Because 90 percent of maize roots were distributed in the 0-30 cm horizon, moisture stress reduced grain yields of the second maize crop, though water was available in the subsoil.

Project Title: Organic matter dynamics and nutrient cycling in tropical agroecosystems. TAMU-410.

Constraints Addressed: Nutrient deficiencies and losses

Project Leaders by Institution:

A. S. R. Juo	TAMU/TAES
L. Hossner	TAMU/TAES

Research Collaborators by Institution:

M. Gandah	INRAN (Niger)
A. Manu	TAMU/TAES
K. Grahammer	TAMU/TAES

PROJECT PROGRESS REPORT

Summary of Research

Maintenance of soil organic matter levels forms the basis of viable soil management systems for sustained economic productivity. Project TAMU-410 is targeting the kinetics of decomposition of soil organic matter, millet residues and legume green manures in the semi-arid tropics.

A greenhouse experiment with the objective of quantifying N release during decomposition of different cowpea plant parts at different growth stages was implemented from June to November, 1990. Cowpeas were grown with ^{15}N to the onset of flowering and to pod filling; i.e. for five and seven weeks, respectively. Decomposition of cowpea leaves, stems and roots was followed during 10 weeks. Laboratory analysis of mineralized N at the four retrieval times have been initiated.

The next activity will be a field experiment in Niger where plant material (millet residues and leguminous green manure) will be added to a sandy Alfisol cropped with millet. Organic material decomposition will be followed in order to evaluate the influence in soil organic matter content and in millet nutrition. The main objectives are (a) to estimate rates of decomposition of millet and legume residues by measuring release of CO_2 and of inorganic N, and (b) to evaluate the contribution of decomposing legumes to the N nutrition of millet. The experiment will be conducted during the 1991 growing season in Niger. Green manure legumes will be cowpea, which is fast growing, and a wild legume well adapted to the environment. Legumes will be grown between the millet plants for six weeks, followed by surface

incorporation and decomposition during the remaining part of the growing season.

Project Title: Agroforestry systems for the humid tropics. NC-4.

Constraints Addressed: Soil acidity
Nutrient depletion and losses
Topographic limitations
Water stress
Weeds

Project Leader by Institution:

C. B. Davey	NCSU

Research Collaborators by Institution:

L. T. Szott	CATIE, IRDC
C. A. Palm	NCSU
A. Ricse	INIAA
J. Sanchez	INIAA
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P. Ruiz	NCSU
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PROJECT PROGRESS REPORT

Summary of Research

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

Several peach palm plantations, ranging from three to ten years old are being used for investigating management techniques to maximize growth rates and fruit production. Fruit production has had variable response to K fertilization but 80 kg/ha appears to be an optimum rate. Nitrogen has been shown to be a limiting nutrient to plantation establishment. An experiment comparing establishment with several leguminous cover crops to establishment with a rotation rice-rice-cowpea followed by a legume cover crop indicates better palm growth for

the latter case. Mucuna cochinchinensis and Centrosema macrocarpum are the best choices for cover crops.

Germplasm selection trials with araza (Eugenia stipitata) and achiote (Bixa orellana) are providing lines with high production potential.

Two different alley cropping trials on acid soil are providing contradictory results. One of the trials on a sandy loam soil has shown no response to the various mulch treatments (Inga edulis, Gliricidia sepium, and Cassia reticulata) or P fertilization and rice yields remain high. The other study on a loamy sand with Inga edulis as the hedgerow species shows low and declining yields without fertilization yields are maintained with fertilization but competition with the hedgerows reduces yields close to the trees. Root pruning of the hedgerows results in increasing rice yields.

A provenance trial of Gliricidia sepium has provided a promising line 14/84 from Guatemala. this provenance grows quickly and survives well on acid soils.

Managed fallows which include a tree component result in higher nutrient storage in the fallow. Once cleared these fallows tend to produce high crop yields then the natural fallow. Using cover crops as managed fallow results in better weed control.

Project Title: Comparative dynamics of production systems. NC-6.

Constraints Addressed: Soil acidity
Nutrient deficiencies and losses
Soil physical limitations
Topographic limitations
Water stress

Project Leader by Institution:

C. A. Palm	NCSU

Research Collaborators by Institution:

P. A. Sanchez	NCSU
L. T. Szott	CATIE, IDRC (Costa Rica)
J. C. Alegre	NCSU
E. T. Elliott	Colorado State University
G. Melendez	INIAA (Yurimagua, Peru)

PROJECT SUMMARY REPORT

Summary of Research

Results from the first four years show clearly the importance of role of topsoil texture on crop performance, which is associated with soil moisture retention capacity. In terms of soil chemical dynamics the low-input, peach palm and multistrata systems showed significantly higher base status and lower acidity than the forest fallow check for three years. This is the residual effect of the ash. The high-input system, produced the most positive change in soil fertility parameters including rapid improvement of subsoil base status. Significant phosphorus leaching was detected in the loamy sand soil. Soil C and N levels ranged from .9 to 1.3% and .07 to .09%, respectively after four years. There were no significant differences among treatments, including the forest fallow. Soil N mineralization ranged from three ng N/g soil/10 days in the high-input to 7.0 ng N/g/10 days in the forest fallow.

Above-ground inputs, in terms of crop residues and/or litterfall, were similar in all managed treatments on the order of 7.5 t/ha, but all were lower than the forest fallow that had close to 12 t/ha.

After three years, the multistrata system produced much more understory biomass than the low-input, shifting cultivation, forest fallow and peach palm systems. Nutrient stocks in the understory biomass and above-ground litter compartments on the treatments with a planted legume showed higher nitrogen levels than with shifting cultivation or peach palm. The multistrata system, with a well established Centrosema macrocarpum understory produced the highest or nearly the highest stocks of nitrogen, phosphorus, potassium, calcium and magnesium, with the low-input system in second place.

Project Title: Integration and utilization of agroforestry and other organic resources in sustainable, low-input farming systems. UH-2.

Constraint Addressed: Nutrient deficiencies and losses

Project Leader by Institution:

Nguyen Hue	UH

Research Collaborators by Institution:

Lalit Arya	UH
Tom Dierolf	UH
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James Hansen UH
Iswandi CRIFC (Indonesia)
H. Suwardjo CSAR (Indonesia)

PROJECT PROGRESS REPORT

Summary of Research

Inexpensive, locally available agroforestry and other organic resources constitute alternatives to lime and chemical fertilizers. Fast-growing, acid-tolerant, nitrogen-fixing trees and ground cover, and other organic residues serve as sources of nitrogen-rich green manures, fuelwood, fodder, substitutes for lime, windbreaks, and soil erosion control measures. The objectives of this project are to: 1) quantify the nitrogen-supplying capacity of nitrogen-fixing trees and cover legumes relative to a standard nitrogen source (e.g. urea); 2) evaluate role of nutrient recycling of trees in low-input, sustainable farming systems; and 3) identify organic compounds responsible for detoxifying aluminum and develop procedures for estimating "lime" equivalence of green manures.

Previous research done in West Sumatra indicated that herbaceous green manuring temporarily alleviated Al toxicity, enhanced P availability, and supplied other nutrients such as K and Mn. The present research was initiated to compare alley cropping, herbaceous green manuring and liming for upland crop production on an acid soil in West Sumatra.

Green manuring and alley cropping were tested as means of improving upland crop production on acid and infertile soils in Sitiung, West Sumatra. In alley-cropping plantings, the tree species Paraserianthes falcataria and Calliandra calothyrus were shown to be well-adapted to the acid and infertile soils at the experimental site in Sitiung. These species produced an average of about four tons of woody dry matter ha/year. Gliricidia sepium did not grow well in this study, producing only about one-half ton of leafy dry matter and about 400 kg of woody dry matter ha/year.

Yields of upland rice and cowpea crops increased with both lime and green leaf manure applications. The highest yields of upland rice and cowpea were obtained when intercropped with Paraserianthes hedges. Crop response to Calliandra alley cropping was less, due to shading competition, and Gliricidia hedges did not grow well enough to influence crop yields. The highest crop yields were obtained in the Paraserianthes plus low lime

rate (750 kg/ha) treatment. This suggests that the beneficial effects of alley cropping with Paraserianthes went beyond simply substituting for lime, and may be beneficial even in areas where upland rice and cowpea crop yields are not limited by soil acidity.

A general philosophy which was followed in designing and managing these experiments was to set fertilizer rates and crop management practices within the ranges of current farmer practice and to deviate from farmer practice only in experimental factors. This "farming systems" approach to research was intended to insure that research results would be more readily applicable to farmers' needs and resources than research conducted under high input, controlled conditions. However, by not making blanket applications of nutrients such as Mg or micronutrients, crop yield responses to treatments could have been confounded with variability in availability of these non-treatment nutrients. The treatment effects which caused significant increases in crop yields, such as response to Paraserianthes alley cropping, were very strong and such technology will hopefully be readily transferred to Sitiung farmers.

Project Title: Pathways of N flow in relation to crop utilization of applied N. CU-110.

Constraints Addressed:

Project Leaders by Institution:

John M. Duxbury	CU
Jean Fruci	CU
Freddy Sanchez	University of Costa Rica

PROJECT PROGRESS REPORT

Summary of Research

Research in this period focused on the effects of sample handling procedures on measurement of the active soil organic nitrogen (ASN) fraction by our newly developed isotope dilution procedure. Air drying sieved soil increased the ASN value for a Collamer soil in long-term arable agriculture from 94±9 to 163±8 kg N/ha and also doubled the amount of N mineralized in a 45-day incubation. Measurements with soil cores (~100g) gave ASN values of 173±14 g N/ha compared to 101±14 kg N/ha for similar weights of unsieved soil. Treatments that had no effect on measured ASN were: 1) sieving soil within a 1-4 mm range, 2) increasing fumigation time from

24 to 48h, and 3) increasing sample size from 20 to 100 g.

The ASN method is operationally defined because the assumption of a discrete pool is an approximation. We have chosen to define the ASN pool as that measured in 40 days of incubation at 20°C or 20 days at 30°C. Extending the incubation time at 30°C to 70 days increased measured ASN values by about one-third of those obtained after 20 days due to participation of less active soil N pools.

Contacts were established with scientists at University of Costa Rica and potential study sites were identified.

Project Title: Tillage, cultural practices, and fertilization effects on infiltration, soil erosion, soil water storage and crop yield. TAMU-403.

Constraints Addressed: Soil physical limitations
Water stress
Nutrient deficiencies and losses

Project Leaders by Institution:

C. W. Wendt	TAMU/TAES
A. B. Onken	TAMU/TAES
Z. Kouyate	IER (Mali)

Research Collaborators by Institution:

A. S. R. Juo	TAMU/TAES
R. L. Baumhardt	TAMU/TAES
D. McCool	USDA-ARS (Washington)

PROJECT PROGRESS REPORT

Summary of Research

Declining soil physical properties in Sahelian soils are caused by low organic matter, high soil temperatures, raindrop impact on exposed soils, and poor tillage practices. These combine to destroy soil structure which result in compaction, reduced infiltration, increased runoff, decreased soil water storage, and soil erosion. Project TAMU-403 concentrates its activities in Mali, and it has completed a long-term experiment on the effects of tillage and fertilization on infiltration, soil water storage, and sorghum yield. A new five-year experiment aimed at determining the effect of different rotations, tillage and crop residue management has been initiated in 1990.

Tillage and fertilization effects soil properties and grain sorghum yield

The effects of tillage and fertilization on grain sorghum water use, growth, and yield were studied for three years at the Agronomic Research Center at Cinzana, Mali. Prior to initiating the studies in 1986, the loam soil (Plinthaquic Kandiustalf) was fallowed. tillage practices studied were undisturbed soil, subsoiling, furrowing, and furrow diking. the tow fertilizer treatments were no-fertilizer (control) and P and N fertilization. Water use, stover yield and grain yield were increased by both tillage and fertilization. Fertilization was more effective than tillage. Research results show that grain sorghum yields can be increased in both wet and dry years through tillage and fertilization in areas of the Sahel that have the climate and characteristics of this study. this activity has been terminated and a report summarizing results for this three-years study is being prepared.

Rotations, tillage, and crop residue management effects on soil properties and sorghum yields

The new, five-year experiment initiated in 1990 at the Agronomic Research Center at Cinzana includes the evaluation of three rotations with legume crops (cowpea, Sesbania, and Dolichos), two tillage systems (ridging and tied ridging), and residue management. Millet is grown on a sandy loam soil, and sorghum on a clay loam soil. Results for the first year of this experiment are being analyzed.

Project Title: Water requirements and low-cost water management technologies for sorghum and millet production. TAMU-408.

Constraints Addressed: Water stress
Nutrient deficiencies and losses
Soil physical limitations

Project Leaders by Institution:

C. W. Wendt	TAMU/TAES
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A. S. J. Juo	TAMU/TAES
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Research Collaborators by Institution:

C. Zaongo	TAMU/TAES

M. J. McFarland TAMU/TAES
R. Lascano TAMU/TAES
R. Norman NAAR Project (Niger)

PROJECT PROGRESS REPORT

Summary of Research

The Sahel is characterized by rainfall which is extremely variable in yearly amount, distribution, and intensity. Low input water management systems and fertilization techniques need to be developed to overcome variability in water and soil resources, but basic information is needed on water requirements of crops grown at different levels of soil nutrient availability.

Project TAMU-408 is focusing on the interactive effects of water and nutrients on sorghum growth in sandy soils in Niger. Field experiments have been conducted in Maradi, Niger. A model will be developed based on the ENWATBAL model developed Lubbock Research Center, Texas. In one experiment, sorghum was planted at two levels of water availability (rainfall and rainfall plus supplemental irrigation), two levels of mulching (0 and 10 ton/ha of crop residues), and two levels of fertilization (0 and 60 N kg/ha). Layout consisted of a split plot where fertility and mulch levels were combined and randomly assigned to 20x8 m individual plots within each water level and over six replications. In a second experiment, the use of residual soil moisture was studied after the normal harvest to produce sorghum or cowpea crops with minimum supplemental irrigation.

Parameters measured included: (a) daily weather data (rainfall, air temperature, relative humidity, wind speed, and incident solar radiation; (b) soil data (profile description and characterization, physical and hydraulic properties, soil moisture and temperature profiles throughout the growing season); and (c) agronomic data (plant height, root distribution, leaf area index, above ground dry matter production throughout the growing season, grain and dry matter yield and quality). Most of the field and modeling data has been collected; statistical analysis and laboratory work is underway.

Project Title: Water use efficiency and soil fertility relationships. TAMU-409.

Constraints Addressed: Water stress
Nutrient deficiencies and losses

Project Leaders by Institution:

A. B. Onken	TAMU/TAES
C. W. Wendt	TAMU/TAES
L. Hossner	TAMU/TAES
Z. Kouyate	IER (Mali)

Research Collaborators by Institution:

M. Gandah	INRAN (Niger)
W. Payne	TAMU/TAES
A. Manu	TAMU/TAES
J. Takow	IRA (Cameroon)

PROJECT PROGRESS REPORT

Summary of Research

Crop utilization of available soil moisture in the Sahelian environment is closely linked with fertility levels. Increased crop production and introduction of new cereal germplasm can be facilitated by minimizing soil physical and chemical constraints. Project TAMU-409 is investigating alternatives for enhancement water-use-efficiency with applied nutrients and cultivar selection. This is a collaborative work with INTSORMIL.

An additional activity included in project TAMU-409 is an experiment on P fertilization on paddy rice being conducted by a Cameroonian AID participant, with technical support from TropSoils.

Water and P use efficiency in sorghum

A study on minilysimeters in rainout shelters was completed. The objective was to examine two grain sorghum cultivars for their ability to extract and more efficiently use P and water and to determine if water use efficiency is a function of P fertilization. Grain sorghum cultivars CSM 63 (from Mali) and TX 7078 (improved) were grown at four levels of P fertilization (0, 15, 30 and 60 mg P kg^{-1} soil) and two levels of available water.

There was not significant difference in grain yield between the cultivars. Differences in root, stem, and leaf dry matter were found due to differential responses to moisture levels and P rates. TX 7078 produced as much grain yield as CSM 63 despite the fact that it is a non-tillering cultivar with fewer heads at harvest. Higher total dry matter and grain yields were obtained when plants were grown without water stress. Total dry matter

produced at anthesis was 18% lower under moisture stress compared to the high moisture regime. Application of 15, 30 and 60 mg P kg-1 resulted in increases of 100, 118, and 118 g of sorghum grain respectively, over the control (no P).

Total water consumed by CSM 63 was greater than TX 7078. Water use efficiency (WUE) computed on the basis of total dry matter was greater for CSM 63 than TX 7078. It was lower, however, when computed on the basis of grain yield. Increasing water supply decreased WUE based on total dry matter. Conversely, WUE based on grain yield increased with increasing water supply. A significant positive linear relationship was found between dry matter produced and transpired water. Also, a simple highly significant relationship was found between harvest index and WUE for both water stressed and non-water stressed treatments.

Water use efficiency in millet

Lysimeter and growth chamber experiments were conducted to determine water use efficiency in millet as affected by P and water supply. Results indicate that: 1) P supply strongly influences amount and distribution of millet biomass under water stressed and on-water stressed conditions; however, relative growth rate and net assimilation rate were relatively unaffected by water and P supply; 2) increasing P availability increases WUE under both water stressed and on-water stressed conditions; 3) water stress increases WUE; and 4) the ratio of photosynthesis to transpiration drops considerably during P stress, thus offering a physiological explanation for lowered WUE. These results offer agronomic and physiological evidence that water conservation in the Sahel will be a relatively ineffective mean of stabilizing and raising millet yields without addressing soil fertility constraints.

Phosphate sources/levels, Mn and Fe uptake, and paddy rice

A pot experiment was conducted in Cameroon using soil from a paddy field to evaluate the effects of three sources of phosphate (bicalcium, tricalcium, and triplesuper phosphates) on the availability of native Mn and Fe to the rice plant and to monitor changes in soil reaction (pH and Eh) under flooded conditions. Research results showed an increase in solution pH and a decrease in Eh with time of flood. Soil solution concentrations of Mn, Fe and P increased with time regardless of source and level of P fertilizer. Mn concentrations in plant

shoots were greater than in rice roots while Fe concentrations were greater in the roots than in the shoots. Shoot Mn concentration ranged from 51 to 115 mmol kg^{-1} and from 19 to 55 mmol kg^{-1} for the roots. Shoot Fe concentration ranged from 7.2 to 14.4 mmol kg^{-1} while root concentration ranged from 323 to 860 mmol kg^{-1}. P fertilizer did not have a consistent effect on availability and uptake of Fe and Mn.

Project Title: Integrated management of crops under variable rainfall conditions in the tropics. CU-6.

Constraints Addressed: Climate variability
Water stress
Site-specifity of management practices

Project Leaders by Institution:

Susan J. Riha	CU
Beverly McIntyre	CU
David Flower	ICRISAT (Kano, Nigeria)
Peter Crauford	IITA (Kano, Nigeria)

PROJECT PROGRESS REPORT

Summary of Research

In collaboration with ICRISAT and IITA, we began field experiments in October 1989 to increase our understanding of water use by C4 cereals growing in the semi-arid tropics (SAT). The research was conducted at IITA's Kano substation.

In our first experiment, begun in October 1989, we examined water use in maize, millet, and sorghum subjected to protracted drought. (All field studies were done during the dry season.) Physiological parameters (stem extension, rooting depth and root length density, leaf area and dry weight, pre-dawn leaf water potential, and stomatal conductance) were measured in addition to daily neutron probe and gravimetric readings of soil water content. Plant interception of radiation was measured daily and hourly mean air and soil temperatures, RH, wind speed and direction, and total incoming solar radiation were recorded on site.

The second experiment, begun in March 1990, under warmer temperatures and higher potential evapotranspiration, allow us to analyze, in conjunction with our first and third experiment, the effects of climatic variables on water use. The third field study began in September 1990

and included examining the effect of leaf area on water use by varying the population density of millet. We are now in the process of analyzing data collected during the three field experiments.

We believe biophysical models that realistically assess the potential of a cultivar to grow and yield at a particular site to be of great significance in the semi-arid tropics. Existing water stress models will be analyzed to determine their adequacy for the SAT. From these studies, we hope to gain insight into cultivars that efficiently use water and develop systems that promote productive yet sustainable agriculture.

Project Title: Management of humid tropical steeplands. NC-5.

Constraints Addressed: Topographic limitations

PROJECT PROGRESS REPORT

Summary of Research

Project cancelled at the end of 1989.

Referred Papers

Elsenbeer, J. and D. K. Cassel. 1990. Surficial processes in the rainforest of Western Amazonia. In: R. R. Ziemer, C. L. O'Loughlin and L. S. Hamilton (eds.). Research Needs and Applications to Reduce Erosion and Sedimentation in Tropical Steeplands. IAHS Publication No. 192.

C. OUTREACH

Project Title: TropSoils Communications. Com-1.

Constraints Addressed: (1) Number and diversity of potential users of TropSoils results
(2) Lack of local expertise and information
(3) Gap between new information and useable knowledge

Project Leader by Institution:

Neil Caudle NCSU

Research Collaborators by Institutions:

All TropSoils participants

PROJECT PROGRESS REPORT

The TropSoils Communications Program supports the research programs and the Management Entity by providing communications services and consultation. In this role, the program: 1) edited all material submitted for the TropSoils Technical Report, 1988-1989; 2) edited, designed, and produced Legume Green Manures: Principles for Management Based on Recent Research (30 pp); 3) edited text of Physical Constraints of root Growth in Savanna Oxisols (in press); 4) provided consultation on usability, documentation and distribution of three computer-based expert systems under development by TropSoils; 5) edited user interface for ADSS system; 6) wrote and distributed several news stories about TropSoils--supplied funding agencies and university administrators with photos and information about TropSoils activities; 7) prepared exhibit, artwork, and slides for CRSP Council--contributed to several Council presentations in Washington, DC; and 8) coordinated distributions of all TropSoils publications, updating and increasing the mailing list.

Project Title: Technical support of research network in the humid tropics. NC-8.

Constraints Addressed: Number and diversity of users
Number and diversity of soils
Information knowledge gap
Lack of skills
Research capabilities

Project Leader by Institution:

T. J. Smyth	NCSU

Research Collaborators by Institutions: National Institute Scientists and USAID Missions in Latin America, Caribbean, Africa and Asia. IBSRAM, TSBF, FAO, ICRAF, CIMMYT, EMBRAPA and INIAA.

P. A. Sanchez	NCSU
D. E. Bandy	NCSU
S. W. Buol	NCSU
J. A. Alegre	NCSU
C. A. Palm	NCSU
W. R. Raun	CIMMYT

PROJECT PROGRESS REPORT

Summary of Research

The II Latin American Workshop on Tropical Soil Management (RISTROP II) was held July 8-14, 1990, in San Jose, Costa Rica. There were 103 scientists representing 43 institutions, distributed among 15 countries who attended the II Latin American Workshop on Tropical Soil Management. The purpose of the workshop was to review research developments in both RISTROP (Red de Investigacion de Manejo de Suelos Tropicales) and CIMMYT's Strategic Agronomic Trials networks, intensify information exchange among collaborators, and modify/update plans for continuation of the research. Representatives from each network site reported on their locally-funded investigations in transferral and adaptation of soil management technology for low input cropping, mechanized continuous cropping, grass-legume pastures, paddy rice, agroforestry, and the Fertility Capability Classification system. Invited speakers reported on recent technological advances in tropical soil management research.

Discussion groups were created for each soil management option and assigned the task of developing recommendations for future network activities. Discussions focused on the identification of specific processes which affected the outcome of field trials across all network sites. Collaborators subsequently identified methodologies which could be used to investigate such processes. Treatment variables were kept to minimum, thus ensuring flexibility in design for site-specific conditions. This was taken as a clear demonstration of the maturity which scientists have gained in the collaborative nature of network research, during the past four years of RISTROP's existence. Workshop participants commended the program for its focus on tropical soil management issues in Latin America. For many national institute representatives this meeting provided a unique opportunity to interact and establish scientific linkages with colleagues who face similar soil management problems across a range of socio-edaphic conditions in Latin America. In addition to the workshop, visits were made to each of the RISTROP experiments at least once during 1990.

Project Title: An expert system for diagnosing and recommending economically feasible, farmer-acceptable and environmentally safe soil-management practices. UH-4.

Constraints Addressed: Number and diversity of soils
Information knowledge gap

Number and diversity of users

Project Leader by Institution:

Russell Yost	University of Hawaii

Research Collaborators by Institutions:

Lalit Arya	UH
Neil Caudle	NCSU
F. Cox	NCSU
I. P. G. Widjaja-Adhi	CSAR
S. Itoga	UH
A. Istiglal	CSAR
Z. Li	UH
M. Oka	CRIFC
A. Onken	TAMU
S. Reid	CU
Vickie Sigman	UH
A. Sofyan	CSAR
Yunizar	CRIFC

PROJECT PROGRESS REPORT

Summary of Research

The Soil Acidity Decision Support System (ADSS) was formerly known as ACID4. ADSS is a computer program designed to implement existing knowledge about crops and use of this knowledge to diagnose and evaluate the impact of soil acidity in a specific farmer's field or site. This program enables the user to figure out what corrective measures are needed, and the approximate economic consequences of these choices. The project objectives are to: 1) translate the existing ACID4 soil acidity expert system into prolog with extensions of improved user interface, multiple-objective consultation, and preliminary natural language; 2) test expert systems for managing soil acidity for performance and integrity relative to requirements and expectations; 3) expand soil data base interface with the expert system by increasing the soil information accessible to the expert system; and 4) add output from TropSoils research into an expert system and provide feedback to researchers on critical information gaps.

The Soil Acidity Decision Support System (ADSS) was initially developed for use by the Center for Soils Research in Bogor, Indonesia, as a collaborating partner of the TropSoils/Indonesia project. ADSS implements the Cochrane equation as a way of determining how much aluminum (Al) in the soil needs to be neutralized with

lime in order to reduce Al toxicity. An economic analysis is also performed that compares the benefits of the probable yield increase form the lime application with the cost of lime, its transport, distribution, and incorporation. ADSS is available in English, but hopefully will soon be translated into Spanish as well.

Knowledge-based or decision support systems can be used in the following scenarios: 1) diagnosis and recommendation (a) where the user is unfamiliar with factors involved in making a diagnosis of growth or production limiting conditions, (b) where the user doesn't know how much amendment is needed to correct a problem, (c) where the user is unaware of limitations or special precautions for application, (d) where the user is not aware of the major cautions that should be exercised in interpreting data, and (e) where the user wishes to evaluate the profit of liming acid soil and its subsequent effect on profits; 2) evaluating alternatives--a study at Purdue University indicated that expert system users evaluated more alternatives when using computer-based decisions aids than when consulting a human expert; and (3) improving the quality of soil research--well-designed decision aids can improve the research process in that one assembles the information needed for the best possible diagnosis and recommendation.

D. BACKSTOPPING

Project Title: Project management--backstopping. UH-6.

PROJECT PROGRESS REPORT

Summary of Research

Personnel matters, accounting, purchasing, and inventory continue to be handled by the on-campus staff to backstop both on-site and on-campus activities. From June to November, 1990, team leader, Dr. Lalit M. Arya, was on leave-without-pay status while carrying out a short-term assignment with Winrock International at the Sukarmi station in West Sumatra. Duties of the team leader were handled by Tom Dierolf during Dr. Arya's absence.

Laboratory support services were provided to the on-site staff during this fiscal year. Soil and plant samples from field trials in Sitiung were dispatched to the University of Hawaii campus for analysis. A total of 778 samples were received.

In-country facilities were not available. The on-site field laboratory in Sitiung was not established to handle a large number of routine sample analyses. Laboratory equipment needed to be replaced, or overhauled by shipping it back to the manufacturer. However, lack of available funds prohibited either option.

Personnel support for backstopping remained at 1.0 FTE.

Project Title: Program backstopping. NC-9.

Project Leader by Institution:

P. A. Sanchez	NCSU

Research Collaborators by Institutions:

B. I. Monar	NCSU
M. Rumble	NCSU
M. Lieber	NCSU
M. Gonzalez	NCSU
D. E. Bandy	NCSU
J. C. Alegre	NCSU
J. C. Palma	INIAA (Yurimaguas, Peru)
G. Melendez	INIAA (Yurimaguas, Peru)

PROJECT PROGRESS REPORT

Summary of Research

Entire program is backstopped with administrative, logistical and laboratory support staff. Program-wide research activities have focused in promoting a worldwide deforestation reduction initiative. This has led AID and EPA to award a grant to the National rEsearch Council to produce an authoritative analyses of alternatives to slash and burn agriculture.

VII. APPENDIXES

A. Graduate Student Thesis Completed

1. Natural Resource Management

Fontes, Mauricio Paulo Ferreira. Interaction of goethite and humic acid in some Oxisols from Brazil. Advisor: S. B. Weed. Ph.D. North Carolina State University. 1990.

Ouattara, Mamadou. A study of two toposequences on the dry valley systems of western Niger (West

Africa). Advisor: L. P. Wilding. Ph.D. Texas A&M University. 1990.

Puentes, Ruben. Soil structure restoration in Vertisols under pastures in Texas. Advisor: L. P. Wilding. PH.D. Texas A&M University. 1990.

2. Sustainable Agriculture Production

Davelouis, J. R. Green manure applications to minimize aluminum toxicity in the Peruvian Amazon. Advisor: P. A. Sanchez. Ph.D. North Carolina State University. 1990.

Ara, M. A. Nitrogen contribution of the legume to grazed pastures in the humid tropics. Advisor: P. A. Sanchez. Ph.D. North Carolina State University. 1990.

Fernandes, E. C. M. Alley cropping on acid soils. Advisor: C. B. Davey. Ph.D. North Carolina State University. 1990.

Payne, William Albert, Jr. Growth and water-use efficiency of pearl millet as affected by phosphorus and water supply. Advisors: L. R. Hossner and C. W. Wendt. Ph.D. Texas A&M University. 1990.

Sow, Abdoul. The relationship between soil water utilization and the phosphorus status of sorghum. Advisors: L. R. Hossner and A. B. Onken. M.S. Texas A&M University. 1990.

Rusman, B. F. Effect of deep placement of lime on soil properties, root growth, water availability, and crop production in acid soils in Sitiung, West Sumatra. Advisor: Lalit Arya. Ph.D. Padjajaran University, Indonesia. 1990.

B. Graduate Student Thesis Work in Progress

1. Natural Resource Management

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.

Coulombe, Clement. Processes of soil degradation/rejuvenation under different land use systems. Advisor: L. P. Wilding. Ph.D. candidate. Texas A&M University.

Sow, Abdoul. Soil and nutrient losses in water runoff as influenced by land-use systems in small watersheds. Advisor: L. R. Hossner. Ph.D. candidate. Texas A&M University.

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

Thompson, Mark. Title not defined yet. Advisor: A. S. R. Juo. M.S. candidate. Texas A&M University.

Grahammer, K. Kinetics of decomposition of soil organic matter, millet residues and legume green manures in the semi-arid tropics. Advisor: A. S. R. Juo. Ph.D. candidate. Texas A&M University.

Doumbia, Mamadou. Acid soil fertility at the Cinzana Station, Mali. Advisor: L. R. Hossner. Ph.D. candidate. Texas A&M University.

Bielders, Charles. Title not provided. Advisor: Philippe Baveye. Ph.D. candidate. Cornell University.

Verburg, Kirsten. Title not provided. Advisor: Philippe Baveye. Ph.D. candidate. Cornell University.

Marcado-Martinez, Eugenio. Title not provided. Advisor: Murray McBride. Ph.D. candidate. Cornell University.

2. Sustainable Agriculture Production

Nurwakera, J. Soil phosphorus dynamics in a Brazilian Amazon Oxisol. Advisor: T. J. Smyth. M.S. candidate. North Carolina State University.

Beck, M. Changes in soil phosphorus fractions under continuous cultivation in a Peruvian Amazon Ultisol. Advisor: P. A. Sanchez. M.S. candidate. North Carolina State University.

Luna, Pedro. Managed fallows in low-input systems in Bolivia. Advisor: P. A. Sanchez. Ph.D. candidate. North Carolina State University.

Glasener, K. Ammonia volatilization from green manures. Advisor: C. A. Palm. M.S. candidate. North Carolina State University.

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

Salazar, A. The effect of phosphorus fertilization on the sustainability of alley cropping. Advisor: C. A. Palm. M.S. candidate. North Carolina State University.

Ruiz, F. Phosphorus dynamics on agroforestry systems. Advisor: C. B. Davey. Ph.D. candidate. North Carolina State University.

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

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

Dierolf, Thomas. Nutrient cycling in alley cropping and its role in maintaining soil fertility. Advisor: R. S. Yost. Ph.D. candidate. University of Hawaii.

Istiglal, Amien. Decision support systems for economically feasible, farmer acceptable and environmentally safe soil management practices. Advisor: R. S. Yost. Ph.D. candidate. University of Hawaii.

M'Intyre, Beverly. Soil water use by C_4 cereals grown in the semi-acid tropics. Advisor: Susan Riha. Ph.D. candidate. Cornell University.

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

1. Natural Resource Management

Buol, S. W., P. A. Sanchez, S. B. Weed and J. M. Kimble. 1991. Predicted impact of climatic warming on soil properties and use. In: Impact of carbon dioxide, trace gases, and climate change on global agriculture. ASA Special Publication No. 53. Madison, WI. 6:71-82.

Buol, S. W. and P. A. Sanchez. 1990. Soil characteristics and agronomic practices for sustainable dryland farming. In: P. W. Unger, W. R. Jordan, T. V. Snead and R. W. Jensen (eds.): Challenge in dryland agriculture: global perspective. USDA, Bushland, Texas. 105:367-370.

Smith, C. W., S. W. Buol and P. A. Sanchez. 1990. Implications of soil mineralogy in the soil fertility capability classification system. Transactions 14th Int. Cong. of Soil Sci. 7:4-9.

Grove, T. and P. A. Sanchez. 1990. Technical options for reducing emissions: sustainable alternatives to slash and burn. Vol. 1: VI.-47-VI.-52. In: Greenhouse gas emissions from agricultural systems. U.S. Environmental Protection Agency, Policy Planning and Evaluation Division. Washington, DC.

Sanchez, P. A., C. A. Palm and T. J. Smyth. 1990. Approaches to mitigate tropical deforestation by sustainable soil management practices. p. 211-220. In: H. W. Scharpenseel, M. Schomaker and A. Ayoub (eds.): Soils on a warmer earth. Developments in Soil Science No. 20. Elsevier, Amsterdam.

Puentes, R. and L. Wilding. 1990. Structural restoration in Vertisols under pastures in Texas. p. 244-249. In: Transactions 14th International Congress of Soil Science, Vol. VII, Commission VII, Kyoto, Japan.

2. Sustainable Agriculture Production

Alegre, J. C., C. Felipe-Morales and B. La Torre. 1990. Soil erosion studies in Peru. Journal of Soil and Water Conservation. 417-420.

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

Mt. Pleasant, J., R. E. McCollum and J. D. Coble. 1990. Weed population dynamics and weed control in the Peruvian Amazon. Agronomy Journal. 82:102-112.

Smyth, T. J. and M. S. Cravo. 1990. Phosphorus management for continuous corn-cowpea production in a Brazilian Amazon Oxisol. Agron. J. 82:305-309.

Smyth, T. J. and M. S. Cravo. 1990. Critical phosphorus levels for corn and cowpea production in a Brazilian Amazon Oxisol. Agron. J. 82:309-312.

Smyth, T. J. and Bastos Joaquim B. 1990. Abudacao Potassica para Milho e Caupi em Latossolo Amarelo alico do Estado do Amazonas. ANAIS 1 Simposio do Tropico Umido 3:173-181, EMBRAPA, Belem, Brazil.

Teixeira, Sonia M. and T. J. Smyth. 1990. Analise Economica da Abudacao Fosfatada parp Systemas de Producao de Milho e Caupi em Cultivos Sucessivos em Solos de Terra Firme do Estado do Amazonas. ANAIS 1 Simposio do Tropico Umido 3:183-193. EMBRAPA, Belem, Brazil.

Palm, C. A. and P. A. Sanchez. 1990. Decomposition and nutrient release patterns of the leaves of three tropical legumes. Biotropica 22: 330-338.

Elsenbeer, J. and D. K. Cassel. 1990. Surficial processes in the rainforest of Western Amazonia. In: R. R. Ziemer, C. L. O'Loughlin, and L. S. Hamilton (eds.). Research Needs and Applications to Reduce Erosion and Sedimentation in Tropical Steeplands. IAHS Publication No. 192.

Sanchez, P. A., C. A. Palm and T. J. Smyth. 1990. Approaches to mitigate tropical deforestation by sustainable soil management practices. In: H. W. Sharpenseel, M. Schomaker and A. Ayoub (eds.). Soils on a Warmer Earth. Dev. in Soil Sci. 20:211-220. Elsevier, New York.

Sanchez, P. A. 1990. Deforestation reduction initiative: an imperative for world sustainability in the twenty-first century. North Carolina Agricultural Research Service Bulletin, 470. Also published, p. 375-382, In: A. F. Bouwman (ed.): Soils and the greenhouse effect. Wiley, New York.

Payne, W. A., C. W. Wendt and R. J. Lascano. 1990. Root zone water balances of three low-input sandy

millet fields of Niger, West Africa. Agron. J. 82:813-818.

Payne, W. A., C. W. Wendt and R. J. Lascano. 1990. Bare fallowing on sandy fields of Niger, West Africa. Soil Sc. Soc. Am. J. 54:1079-1083.

Fox, R. L., N. V. Hue and W. W. McCall. 1988. Chlorosis in macadamia induced by lime, phosphate, manganese and aluminum. J. Hawaiian and Pacific Agriculture. 1:10-15.

Hue, N. V. 1990. Interaction of $Ca(H2_2PO_4)_2$ applied to an Oxisol and previous sludge amendment: soil and crop response. Commun. Soil Sci. Plant Anal. 21:61-73.

Manjunath, A., N. V. Hue and M. Habte. 1989. Response of Leucaena leucocephala to vesicular-arbuscular mycorrrhizal colonization and rock phosphate fertilization in an Oxisol. Plant and Soil. 114:127-133.

Dierolf, T. S., L. M. Arya and R. S. Yost. 1989. Root distribution in an alley-cropped system. Nitrogen Fixing Tree Research Reports. 7:9-11.

3. Outreach

Szott, L. T. and C. E. Castilla. 1990. El programa de Suelos Tropicales de la Universidad Estatal de Carolina del Norte Esfuerzo Colaborativo entre el INIAA y NCSU. En: FUNDEAGRO: Estrategias para el desarrollo de la investigacion agropecuaria en la Selva Alta y Baja del Peru. Fundacion para el Desarrollo del Agro, Lima, Peru. p. 37-64.

D. Special and Miscellaneous Reports Published

1. Natural Resource Management

Manu, A., S. Geiger, A. Pfordresher, E. Taylor-Powell and S. Mahamane. 1990. The Integrated Management of Agricultural Watersheds. Baseline Studies and Project Feasibility. Final Report submitted to USAID/Niamey. TropSoils/TAMU/INRAN/ USAID/Niamey. 112 p. September, 1990.

Taylor-Powell, E. 1990. Description of the zone, land tenure and indigenous knowledge of soil management at the Hamdallaye watershed. Consultancy

report prepared for TropSoils. 55 p. Niamey, January, 1990.

Geiger, S. C., A. Manu and A. Bationo. 1990. Modifications des propietes chimiques d'un sol dunaire suite a des apports a long term de residues et d'engrais. p. 129-139. In: Berrada, A., I. Mahaman and M. Gandah (eds.) Les Actes du Seminaire National sur l'Amenagement des Sols, la Conservation de l'Eau, et la Fertilization. February 20-24, 1989. INRAN, Tahoua, Niger.

Mahamane, Saadou. 1990. Vegetation Survey in the Agricultural Watershed at Hamdallaye. Consultancy report prepared for TropSoils. 56 p. Niamey, November.

Chase, R. and E. Boudouresque. 1989. A study of methods for the revegetation of barren, crusted Sahelian forest soils. p. 125-135. In: Soil, Crop, and Water Management in the Sudano-Sahelian Zone. Proc. of an International Workshop, January 11-16, 1987, ICRISAT Sahelian Center, Niamey, Niger.

Wilding, L. 1990. Interim Report of Peanut CRSP/ TropSoils Program (Burkina Faso). Report on joint TropSoils/Peanut CRSP regarding characterization of soils of Peanut CRSP research sites in Burkina Faso. 33 p. College Station, November.

Bachir, M. 1990. Rapport de Stage aux USA sur le Systeme d'Information Georgraphique (GIS). Final Report on Training Mission, Niamey, NIger.

Man, A., S. C. Geiger, A. Berrada and J. W. Scott-Wendt. 1990. Microvariabilite dans le Sahel: Un Apercu general. p. 117-128. In: Berrada, A., I. Mahaman and M. Gandah (eds.) Les Actes du Seminaire National sur l'Amenagement des Sols, la Conservation de l'Eau, et la Fertilization. February 20-24, 1989. INRAN, Tahoua, Niger.

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2. Sustainable Agriculture Production

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3. Outreach

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Casanova, Eduardo. 1990. Manejo de suelos en cultivos de importancia agricola en los Llanos Centrales de Venezuela. RISTROP II Workshop, San Jose, Costa Rica. July 8-14.

Amezquita, E. 1990. Respuesta de los cultivos a la fertilizacion en areas de agricultura intensiva. RISTROP II Workshop, San Jose, Costa Rica. July 8-14.

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Sanchez, Pedro A. 1990. Iniciativa para la reduccion de la deforestacion: un imperativo para la sostenibilidad del mundo en siglo veintiuno. RISTROP II Workshop, San Jose, Costa Rica. July 8-14.

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F. Special Activities Related to Management of Tropical Soils

1. Natural Resource Management

The Integrated Management of Agricultural Watersheds. Presentation by A. Manu at the Technical TropSoils Session, San Antonio Texas, October, 1990.

Consultation with Peace Corps volunteers (Foresters) on a research utilizing brush to protect young seedlings planted on plateaus in Niger. S. Geiger, TAMU/TAES-Niger.

Presentation of a seminar to Peace Corps trainees on agronomic/agroforestry systems in the Sahel from a soil productivity perspective (November 1989 and November 1990). S. Geiger, TAMU/TAES-Niger.

M. Bachir, Head of the Department of Statistics of the DRE/INRAN, Niger, received short-term training (July-October, 1989) on the utilization of Geographic Information Systems. It included: (2) training course on the utilization of ARC/INFO, (b) visits to Dr. R. Maggio (GIS Laboratory, Department of Forestry, TAMU); Dr. G. Stutte (Horticulture Department, University of Maryland, use of remote IR videography in horticulture); Dr. Pederson (GIS Laboratory at Penn State University, use of GIS on natural resource management); and Dr. J. Doneley (USGS Remote Sensing/GIS facilities in Virginia); (c) visit to GIS laboratories of the SCS at Fort Worth, Texas; (d) set up of ARC/INFO system purchased for Niger (install hardware, become familiar with software, and troubleshooting); and (e) attending ASA meeting at Las Vegas.

Potential uses of GIS in Niger. Seminar presented by M. Bachir to the faculty and graduate student

body of TAMU Soil and Crop Sciences Department, College Station, Texas. October 1989.

Domaines d'application du GIS Au Niger. Seminar presented by M. Bachir to staff at DRE/INRAN, Niamey, Niger. September 1989.

2. Sustainable Agriculture Production

Castilla, Carlos. 1990. Seminar on Tropical Pastures Program. INIAA. Lima, Peru. February.

Fernandes, E. C. M. 1990. Agroforestry in the tropics. Harnett County Rotary Club.

A general NCSU presentation on sustainable soil management alternatives to slash and burn agriculture was given at the following functions in 1990:
- Soil Science Society of North Carolina, Raleigh, January 16.
- Population Course, UNC, Chapel Hill, February 28.
- La Jota Experiment Station, IBTA, Chapare, Bolivia, March 27.
- NCSU College of Agriculture and Life Science's Global Change Symposium, April 9.
- Rockefeller Foundation Media Seminar, Annapolis, Maryland, May 13.
- Chiledze Research Station, Lilongwe, Malawi, May 19.
- RISTROP II Workshop, Sane Jose, Costa Rica, July 12.
- Cornell University, September 11.
- EMBRAPA Agroforestry REsearch Center, Manaus, Brazil, September 14.
- EMBRAPA UEPAE de Porto Velho Station, Rondonia, Brazil, September 21.
- Secretaria de Agricultura, State of Amazonas, Manaus, Brazil, September 26.
- Conservation Sustainable Development Courses, Duke-NCSU, October 9.
- Symposium on Sustainable Agriculture, American Society of Agronomy, San Antonio, Texas, October 23.
- National Resources Symposium, Instituto Colombiano Agropecuario, Bogota, Colombia, November 14 (presented by Dale Bandy).

C. Zaongo, a graduate student from Burkina Faso, is conducting field research at Maradi, NIger. He will return to TAMU in March 1991.

Arya, Lalit and Thomas Dierolf. 1990. TropSoils results on deep liming and organic material management were used to educate several groups of local extension workers. University of Hawaii/CSAR, Indonesia.

Arya, Lalit and Thomas Dierolf. 1990. Scientists and technicians from the Sukarami Agricultural Research Institute for Food Crops (SARIF) have often held discussions with TropSoils staff. They have made extensive use of TropSoils information in formulating their research. University of Hawaii/CSAR, Indonesia.

Arya, Lalit and Thomas Dierolf. 1990. Several groups of scientists, teachers, and students from West Sumatra and neighboring provinces have visited the TropSoils Project for educational purposes. These visits have involved informal discussions with the TropSoils staff, briefings, and tour of the facilities and field trials. Visitors from outside Sumatra have also toured the project, and include personnel and consultants from other projects such as USAID, GOI officials, and the World Bank. University of Hawaii/CSAR, Indonesia.

Cahn, M. D. 1990. Leaching of nitrate and cations in a Brazilian Oxisol. Department of Soil, Crop and Atmospheric Sciences. Cornell University.

3. Outreach

Hanson, R. G. 1990. Seminar - The Soil Management CRSP role in natural resource management and sustainable agriculture production. International Fertilizer Development Center, Muscle Shoals, Alabama. May 24.

Hanson, R. G. 1990. Seminar - The Soil Management CRSP. College of Agriculture, University of Missouri, Columbia, Missouri. May 15.

Hanson, R. G. 1990. Seminar - TropSoils: An international program for improving soil management in the tropics. College of Agriculture and Life Sciences, University of Minnesota--Twin Cities. August 22.

NCSU. 1990. A six-minute professional quality video presentation on NCSU TropSoils Project, produced by NCSU Broadcasting Services.

Caudle, Neil C. 1990. Communications participation in network. RISTROP II Workshop, San Jose, Costa Rica. July 8-14.

Caudle, Neil C. 1990. Soil and water priorities for the next century. Served on Natural Resource Council. National Academy of Sciences.

Caudle, Neil C. Co-investigator "Socio-economic impact analysis of the technologies generated by the Soil Management and other CRSPs in the humid tropics." TropSoils/USAID.