TropSoils

Administrative Report

1981-1986

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About the Cover

In the Sahel of Africa and throughout the tropics, people depend on soil resources for their crops, the fodder for their animals, even the bricks in the walls of their homes. TropSoils conducts its research with the needs of farmers and their families in mind. We recognize that, in developing nations around the world, the lives and livelihoods of each generation will depend on the careful and sustained management of our soil resources. *Photo and design by Neil Caudle, Department of Agricultural Communications, North Carolina State University.*

About this Document

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Foreword

The initial grant from the Agency for International Development for funding the Soil Management Collaborative Research Support Program was for the period September, 1981 – September, 1986. An amendment extended the final date to December, 1986. This report is a summary of the goal, organization, achievements, participating personnel and expenditures relevant to the program for this period.

C. B. McCants, Director
Management Entity

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Summary

TropSoils, the working name used for the Soil Management Collaborative Research Support Program, was initiated in 1981. During its inaugural five-year period, TropSoils has made recognized achievements that are consistent with the spirit and intent of the Title XII legislation under the U.S. foreign assistance program.

The TropSoils leadership has been provided by the administrations and research faculty of Cornell University, the University of Hawaii, North Carolina State University and Texas A&M University, and by the national agricultural research institutions in Brazil, Indonesia, Mali, Niger and Peru. The base funding was provided by the U.S. Agency for International Development, but major support was provided, also, by the universities and the collaborating national institutions. The framework of the program and initiatives undertaken has resulted in an extensive collaborative effort involving 343 scientists and support personnel from 53 institutions in 30 countries.

Because of their association with the research program, 80 people from 26 countries have received advanced training and first-hand experience. This training will enable them to identify soil-management problems, conduct research, and provide effective leadership in developing countries.

The evidence obtained by TropSoils scientists confirms that many of the basic principles established through work with soils in temperate regions apply also to those in the tropics. Results from soil management practices based on these principles provide information to predict with reasonable accuracy the outcome of practices at other locations and under other conditions.

This report presents 30 brief descriptions of major TropSoils achievements during the five-year period. Many of these illustrate the ways in which established soil-management principles and new information can be applied for the practical solution of on-farm problems in developing countries.

Grant Goal and Purpose

The goal of this grant is to develop and adopt improved soil-management technology that is agronomically, ecologically and economically sound for developing countries in the tropics.

The purpose of this grant is to have the Grantee organize and mobilize the financial and human resources necessary for mounting a major multi-institutional US/LDC collaborative effort of research and training in soil management.

Organization

The basic organization of the Soil Management Collaborative Research Support Program (SM-CRSP) is set forth in the grant document. The identification of the various components and their responsibilities follows:

Management Entity

The Management Entity is the recipient of the grant and has overall responsibility for program performance and fiscal management. Funds were disbursed to the participating universities in accordance with guidelines in the grant. Adjustments were made as considered desirable to enhance the total effort. Administrative support was provided to the lead universities in developing agreements with collaborating countries, in expediting requests and procedures, and in program evaluation. Guidelines on detailed administrative actions were provided to the participating universities via a manual, "Policies and Procedures for the Soil Management CRSP," which was developed from published AID policies and procedures.

Charles B. McCants, Director, TropSoils Management Entity

Organization

Mamadou Ouattarra of INRAN; member of TropSoils' Board of Directors

Lead Universities

One university was assigned the lead role for each primary research site and, as such, had the major responsibility for conducting the program at that location. This procedure involved developing programs of mutual interest with the collaborating host country institution, assignment of personnel and providing operational oversight. The lead universities and the country location for each primary research site are:

Cornell University—Brazil
University of Hawaii—Indonesia
North Carolina State University—Peru
Texas A&M University—Niger

Universities which, in addition to a primary site, also conducted research in other countries are:

North Carolina State University—Indonesia and Brazil
Texas A&M University—Mali

Mohammed Sudjadi of the Center for Soil Research; member, TropSoils Board of Directors

John Coulter of the World Bank; member of TropSoils' External Evalutation Panel

Board of Directors

The Board is composed of eight members, one representative from the administration of each lead institution and one representative from each collaborating country with a primary research site. An executive committee was formed consisting of the board members from the lead universities. The chair for the Board is elected by the full Board from members of the executive committee. The Board reviewed and took action on recommendations from the Management Entity on policy issues affecting the overall program and fund allocations to the lead universities. Differences between the Board and the Management Entity on critical issues were resolved before actions were taken.

Technical Committee

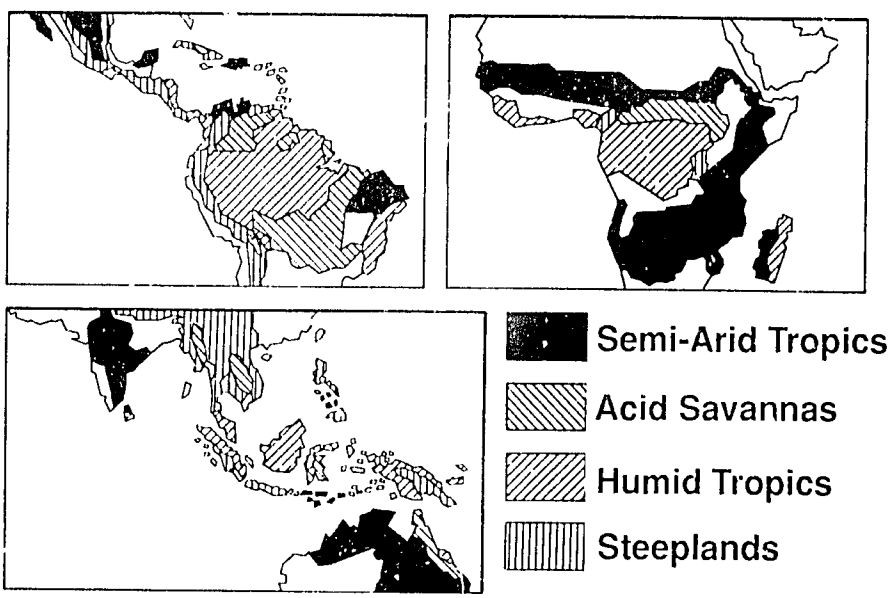
This committee is composed of the four program coordinators (referred to as "principal investigators" in the grant document). They keep each other informed on respective program developments, discuss topics of mutual interest and promote activities of common consent.

External Evaluation Panel (EEP)

The External Evaluation Panel is composed of three members, all of whom were on the Advisory Committee in planning the SM-CRSP. Reviews of individual programs and the overall CRSP were made by the EEP in response to Management Entity requests. The decision to schedule a review was based on the stage of development of the program, concerns on progress or funding status and considerations on changes in research objectives. The reports of the EEP were submitted to the Management Entity for distribution. The recommendations were used in making decisions on revisions in programs and operations.

Program Structure

The Planning Entity recommended and BIFAD and AID approved the plan that the Soil Management CRSP would be organized around four agroecological zones: humid tropics, semiarid tropics, acid savannas and steeplands. Each zone is representative of large areas within the developing countries and has one or more primary research sites and a designated U.S. university or universities to provide the leadership. Secondary or extrapolation sites within the zones were established as technical information became available. In addition to serving a lead role in one zone, a university may also provide support in another zone. The geographic areas covered by the zones are shown below, and pertinent details are summarized in the sections that follow.



Agroecological zones of the tropics

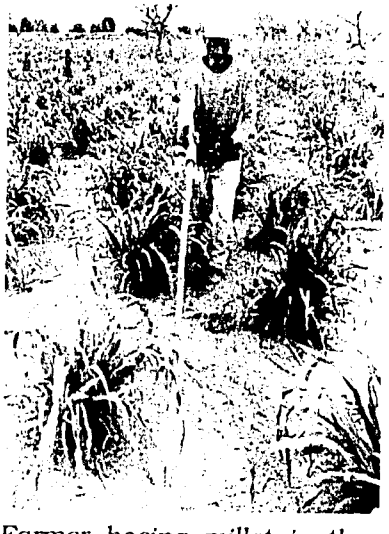
Women planting corn on steep slopes in the humid tropics of Peru

Humid Tropics

This zone is defined as the portion of the tropics with no more than three months' dry season. In the terminology of Soil Taxonomy, dominant soils are in the udic moisture regime and in the isohyperthermic or isothermic temperature regime. The native vegetation is tropical rain forest. Two primary research sites were established:

- Yurimaguas, Peru with North Carolina State University (NCSU) as the lead institution in collaboration with INIPA.
- Sitiung, West Sumatra, Indonesia with the University of Hawaii as the lead and NCSU as the support university. The host country collaborator is AARD through its Center for Soils Research.

In addition, NCSU has a secondary research site at Manaus, Brazil, in collaboration with EMBRAPA.



Farmer hoeing millet in the semiarid tropics of Niger

Semiarid Tropics

The semiarid tropics are defined as the portion of the tropics characterized by a protracted dry season of six to nine months duration. In Soil Taxonomy terminology, dominant soils are the drier end of the ustic soil moisture regime and are in the isohyperthermic temperature regime. The primary research site is in Niger, with a base of operations at Niamey. Texas A&M University provides leadership in collaboration with INRAN. A secondary research site is located in Mali, in conjunction with IER.

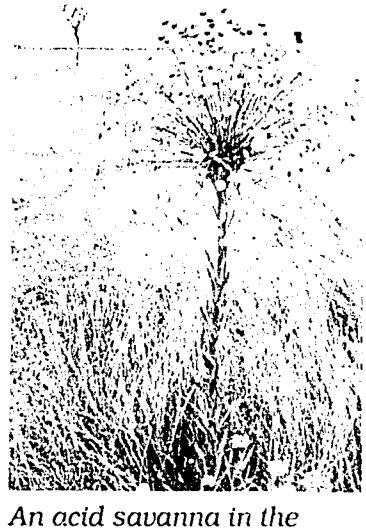
Program Structure

Acid Savannas

This zone is defined as that portion of the tropics with a strong dry season of four to six months duration, savanna vegetation and predominantly acid soils of the orders Oxisol and Ultisol. They are in the ustic moisture regime and the isohyperthermic or isothermic temperature regimes. The primary research sit is at Brasilia, Brazil. The lead institution is Cornell University and the collaborator is EMBRAPA through its CPAC research center. A support role was provided by North Carolina State University.

Steeplands

The Steeplands are defined as the zone with steep, densely populated regions where soil erosion is a major concern. Soil properties, moisture and temperature regimes vary. Funding for research in this zone was not included in the initial grant or subsequent amendments. Nevertheless, soil-management practices relevant to this agroecological condition have been researched in the other activities and pertinent information has been obtained.



An acid savanna in the Cerrado of Brazil

Scope of Work

The scope of work employed is essentially the same as set forth in the grant document.

Humid Tropics—Peru

The initial plan specified that the work would be conducted by North Carolina State University, Cornell University and the host institution. Formal approval was received from AID to shift the Cornell University effort from Peru to the acid savannas of Brazil. The focus of the program in Peru was not altered by this action and is summarized as follows:

1. Develop production systems that require lower inputs for annual crops, while maintaining ongoing systems.
2. Screen cultivars of currently grown or potentially useful crop plants for tolerance to aluminum, low phosphorus levels and efficiency of plant nutrient use.
3. Develop productive and persistent grass/legume pasture systems in cooperation with Centro International de Agricultura Tropical.
4. Utilize biological fixation to the maximum possible extent, with emphasis on legume/rhizobium combinations.
5. Develop alternative land clearing methods, monitor changes in soil physical properties and devise means to correct soil compaction problems.
6. Determine the potential of managed fallows.
7. Incorporate shrubs, trees and other perennial crops into a limited number of annual crop systems.
8. Validate systems of continuous farming technology with farmers in the area, selecting farms which represent the broadest possible range of typical soils.

9. Characterize soils of all experimental sites, on the experiment station and on cooperating farms, according to U.S. Soil Taxonomy and the Fertility/Capability Classification System.
10. Determine the application, utilization, depletion and accumulation of plant nutrients to anticipate problems and minimize input cost, and to obtain a true measure of the value as well as the cost of supplying fertilizer, lime, manure or compost.
11. Disseminate information about the results of the studies to research and extension organizations throughout the humid tropics.

Humid Tropics—Indonesia

The University of Hawaii, the lead institution, and North Carolina State University, the support institution, in collaboration with the Soil Research Institute, Bogor Agricultural University and the Central Research Institute for Agriculture, were to undertake field work in Sumatra, Indonesia directed to the following objectives:

1. Characterize the soil of the experimental sites.
2. Test the most promising methods of land clearing and select one or more appropriate for existing conditions.
3. Monitor the effects of clearing methods on soil physical properties and identify or devise means for correcting undesirable effects.
4. Determine the amounts of fertilizer and lime needed periodically to produce satisfactory crops and to sustain yields at levels profitable for the farmers. This research should include monitoring the nutrient status of farmers' fields, input costs, and the returns from sales plus value of household food consumption.

5. Evaluate the potential of grass/legume pasture mixtures in the farming system.
6. Apply and assess the efficacy of soil-conservation measures to typical areas.
7. Find management systems that minimize energy needs to the extent possible given local limitations on land, manpower and markets.
8. Assess the likes, dislikes, needs and resources of farmers of the area to guide research in lines likely to be beneficial.
9. Disseminate the results of the research to other areas in the humid tropics.

Semiarid Tropics

The grant specified that the field program would be undertaken in Niger and Upper Volta. The primary site was established in Niger and discussions were held with host country and USAID personnel in Upper Volta to determine the feasibility of a secondary site in that country. Due to extensive commitments to existing projects by potential collaborators in Upper Volta, and thus little available time to participate in a SM-CRSP, the government and mission personnel suggested that we maintain communications with them and share relevant information but not to establish a site in the country. Contacts were then made with governmental and USAID officials in Mali and a mutually agreeable program developed for a secondary research site in that country. The scope of work employed in Niger and Mali are in agreement with the one given in the grant document:

1. Characterize the soil at experimental and cooperative sites according to U.S. Soil Taxonomy and the Fertilizer/Capability Classification system.
2. Devise and test methods to prevent or diminish soil crusting.

3. Test and select the most practical means of soil erosion control, measuring losses to water and wind to the extent possible.
4. Develop low-input soil-management systems to maximize the use of soil moisture.
5. Evaluate crops and rhizobia for tolerance to high temperatures, drought, low phosphorus and acidity/soluble aluminum or manganese.
6. Determine how to monitor and adjust plant nutrient balances to sustain yields on a profitable basis.
7. Investigate alternatives to the system of shifting cultivation commonly practiced in the semiarid tropics.
8. Conduct cooperative trials with farmers to obtain an assessment of current and modified technology under normal management capability.
9. Disseminate results of research to other areas in the semiarid tropics.

Acid Savannas

On October 28-29, 1981, the Technical Committee recommended and the Board of Directors approved a recommendation that "...the primary emphasis of the Cornell component of the Soil Management CRSP be shifted from the humid tropics, as specified in the grant document, to the acid savannas, with operational headquarters at the CPAC center, Brasilia, Brazil..." This recommendation was transmitted to the AID Program Manager on November 2 with a request that the grant be amended to encompass this action. Amendment No. 3, dated July 12, 1982 and signed by the AID Grant Officer, formally approved this change. The amendment recognizes Cornell University as the lead institution for the program in the acid savannas, with a support role by North Carolina State University, and the following scope of work:

1. Characterize the soil of the experimental sites.
2. Seek ways to reduce the cost of lime and fertilizer on the acid, infertile soils.
3. Develop practices to maintain an adequate balance of Ca, K and Mg in soils of the region.
4. Estimate the economic returns from lime and fertilizer use under present circumstances and a range of possible cost/price/yield response scenarios.
5. Explore ways to increase the rooting depth of field crops and pastures.
6. Identify crops that may tolerate adverse soil conditions or extract essential plant nutrients more efficiently, reducing the amount of fertilizer and lime needed to produce a satisfactory crop.

Chronology of Major Events

Planning, Initiation and Extension of the SM-CRSP

May, 1979	Grant awarded to North Carolina State University, the planning entity, to develop a detailed plan for an international soil-management research program.
October, 1980	Final proposed plan submitted by the planning entity to AID and JRC.
September, 1981	AID approved establishing and funding the SM-CRSP and issued a grant to NCSU, the Management Entity.
January, 1982	Management Entity issued subgrants to participating universities.
March, 1985	Management Entity submitted formal request to AID for three-year extension of the program.
May, 1985	JCARD approved request for extension.
September, 1986	AID issued a new grant to support the three-year extension of the program.

Humid Tropics—Peru

October, 1981	North Carolina State University advised that AID had funded the SM-CRSP.
January, 1982	Subgrant issued by the Management Entity to NCSU.

Since NCSU had an ongoing soil-management research program in the humid tropics of Peru and Brazil, no formal negotiations with the host countries were necessary. The programs in place were continued in part or expanded and new ones initiated in accordance with the plan of work.

Humid Tropics—Indonesia

October, 1981	The University of Hawaii advised that AID had funded the SM-CRSP.
January, 1982	Subgrant issued by Management Entity to UH.
March, 1982	UH and Management Entity submitted proposed Memorandum of Understanding to AARD.
June, 1983	Indonesia approves Memorandum of Understanding.
June, 1983	Senior scientists from UH and NCSU posted in-country and on-site work initiated.

Semiarid Tropics—Niger and Mali

October, 1981	Texas A&M University advised that AID had funded the SM-CRSP.
January, 1982	Subgrant issued by Management Entity to TAMU.
March, 1982	TAMU and Management Entity submitted proposed Memorandum of Understanding to INRAN (Niger).
June, 1983	Niger approves Memorandum of Understanding.
July, 1983	Senior scientist posted in country and on-site research initiated.
June, 1983	TAMU, Management Entity/SM-CRSP and Management Entity/INTSORMIL submitted Memorandum of Understanding to IER (Mali).
March, 1984	Mali approves Memorandum of Understanding.
July, 1984	Program in Mali initiated.

Chronology of Major Events

Acid Savannas

October, 1981	Cornell University advised that AID had funded SM-CRSP.
November, 1981	Management Entity requested AID to amend grant to include acid savannas component with CU as lead university.
January, 1982	Subgrant issued by Management Entity to Cornell University.
July, 1982	AID approved request to amend grant.
July, 1982	Proposed Memorandum of Understanding submitted to EMBRAPA.
July, 1983	Memorandum of Understanding approved by Brazil.
July, 1983	Senior scientist posted in Brazil and on-site work initiated.

Guarana

The first step toward conserving natural resources in developing countries is a stable agriculture and effective soil management. The proper management of one acre of permanent cropland in the humid tropics can prevent the need for clearing about five acres of tropical rainforest per year. The same principle applies to savannas and steeplands, or the dry lands of Africa's Sahel.

TropSoils develops soil-management technologies that will help farmers grow more food, while conserving natural resources. For example, TropSoils studies have begun assessing the soil-fertility requirements of guarana, an important cash crop on small farms in the Amazon. Guarana, whose seed is used in a popular soft drink, is native to tropical forests and adapted to acid soils. As a permanent crop, it can help prevent erosion and stabilize agricultural production.

The work with guarana is one example of TropSoils' emphasis on the long-term sustainability of tropical agriculture. All of the examples that follow illustrate this approach, and are representative of TropSoils' achievements over the last five years.

Study uncovers subsoil compaction in monocropped Oxisols

Research into the long-term effects of continuous cultivation has uncovered evidence of serious compaction in Oxisols, the dominant soils of acid savannas in Africa and South America. Oxisols are generally well-suited for mechanized tillage because of their excellent physical structure. It was previously thought that acidity and infertility would be the only significant soil-based constraints to crop production in these soils.

But after several years of continuous crop production at the research site, scientists have reported unexpected decreases in crop yields. The results of an intensive investigation suggest that long-term monocropping with mechanized tillage compacts the subsoil and restricts root development, even when water and nutrients are ample. In tropical Oxisols, there is no natural cycle of freeze-thaw or shrink-swell to help regenerate soil structure.

The compaction does not appear to be permanent, however. Studies indicate that proper tillage and crop management will correct the problem. Several such techniques are being investigated under a range of conditions. *Cornell University.*

Eric Stoner at research site near Brasilia

Gypsum improves subsoil chemical properties

By studying the effect of gypsum amendments on acid-savanna soils, scientists have revealed some of the mechanisms that govern availability of plant nutrients in the subsoil. The studies show that calcium and sulfate retention are dependent on the equilibrium concentration of these ions in solution. While calcium retention was almost linearly dependent on its concentration, sulfate tended to approach a maximum adsorption which was not reached within the experimental range studied.

Calcium was adsorbed as an exchangeable cation without affecting the pH of the soil or the total surface positive charge. Sulfate was adsorbed by a ligand exchange mechanism that caused displacement of hydroxyls from the surface, raising the pH of the soil solution. At the same time, sulfate caused an increase in the total negative charge.

Data from this study provide support for the specific adsorption mechanism by which sulfate is adsorbed in these soils. This mechanism affects the balance of charge in the soil and can be used as a way to reduce cation leaching. Application of gypsum increased the retention of both calcium and sulfate, as well as the total cation exchange capacity. This can have some practical use because of the importance of these nutrients.

While lime and gypsum both help offset soil acidity and supply calcium to plants, gypsum reaches the subsoil in greater amounts, and therefore does a better job of promoting deep roots. *Cornell University.*

Color can indicate soil's crop-production potential

Results from the Cerrado of Brazil indicate that the crop-production potential of two common soil types—red-yellow and dark-red—may vary with seasonal shifts in the water table. Because water-table level affects plant growth, drought tolerance and tillage practices, an ability to predict drainage characteristics from soil color patterns would be important.

For example, precipitation data show a two- to three-week dry period in February, which is typical of the regional climate. Scientists have observed that, in soils on the Cerrado's high plateaus, water tables are typically higher in the red-yellow than in the dark-red soils. Crops vulnerable to water stress at this stage of the growing season might benefit from moisture available in a red-yellow soil whose water table was within two meters of the surface. Further data analysis is expected to produce recommendations for diagnostic criteria to be used in classifying these soils. *Cornell University.*

Legumes may reduce need for fertilizer nitrogen

While legume green manures can supply all or most of the nitrogen needed by a succeeding food crop, adapting them for use on the farm requires careful screening and management. It is especially important to select legumes whose nitrogen-fixing potential and mineralization rates fit the requirements of the crop.

Field experiments in the acid savannas have found that legumes can fix from 60 to 170 kg of nitrogen per hectare. Nitrogen mineralized from mucuna, one of the legumes evaluated, was sufficient to produce nearly seven tons of corn grain per hectare. This mineralization was very rapid for about 40 days, then slower for the following 60 days. Among legumes, quantities of nitrogen supplied to the corn crop (expressed in fertilizer-nitrogen replacement values to the succeeding corn crop) ranged from 87 to 192 kg per hectare. Also, there were striking similarities between legume nitrogen and fertilizer nitrogen, both in the recovery of mineralized nitrogen by the plants and the rate of nitrogen loss from the rooting zone. *Cornell University.*

Walter Bowen with mucuna, a legume green manure

Incubation procedures predict nitrogen availability

Scientists working with soils from the acid savannas have found a way to screen various legumes for their potential as green manures by measuring nitrogen in incubated soil samples. While the method is not intended as a general soil test for available nitrogen, it can quickly evaluate gross differences in the amount of nitrogen provided by legumes incorporated in the soil. This is important because the expense of screening legumes for various soils, crops and climates has constrained the development of legume green manures as sources of nitrogen for food crops.

The studies have revealed several factors influencing the accuracy of predictions from the incubation procedure. Correlations between nitrogen mineralized and nitrogen uptake (or yield of corn) were best when the soil samples were prepared for incubation immediately after being taken from the field. Extended storage of soil samples before incubation substantially reduced the correlation. Also, vigorous disturbance of the soil caused a significant increase in nitrogen mineralization. However, if there was some degree of soil aggregation, soil disturbance had little effect on nitrogen mineralization. *Cornell University.*

Soil variability a major factor in land use

Using new geostatistical techniques, TropSoils scientists are finding ways to understand a serious problem on farms and research sites around the world: soil variability. Results from the transmigration area of West Sumatra, Indonesia have shown that soil properties often vary dramatically, over distances as great as several kilometers or as small as a few meters. This variability leads to uneven crop production and a patchwork pattern in fields, a problem for farmers, scientists and land-use planners alike.

The geostatistical tools developed to deal with variability provide a useful method for measuring and quantifying variability, not only on West Sumatra but throughout the tropics. The approach will also contribute to the next generation of expert systems and geographical information bases designed to help the user manage crops and soils. *University of Hawaii.*

Family welfare central in resource allocation

Studies with transmigrant farmers indicate that advanced crop-production technologies are not likely to succeed unless they accommodate an important factor in the allocation of resources—family welfare. On transmigrant farms, sustaining life is more important than making a profit, and the farmer with limited resources will take very few risks when survival is at stake.

Social scientists in West Sumatra, Indonesia surveyed transmigrant farmers in order to learn how families apply their resources to food production and what factors might influence them to accept new technology. The studies found that many farmers continue to use only small amounts of fertilizer and pesticides, even though most acknowledge that using more would boost their crop production. In the hierarchy of spending, fertilizer ranked third after food and seed. Apparently, other needs and goals were more important to the family.

The studies have concluded that an approach that recommends increasing yields by boosting fertilizer use alone will not likely be readily adopted by these farmers. Technologies more likely to be adopted would be those that increased productivity without increasing costs significantly, such as improving the efficiency of fertilizers. Other technologies might succeed if benefits were so great that families were willing to redirect resources now devoted to other activities. *University of Hawaii.*

TropSoils' social studies have underscored the important role of women in decision-making on farms in the transmigration areas of Indonesia.

Ethnic dfferences affect design of farming systems

Social scientists studying transmigrant farmers in Indonesia have used cognitive "maps" to discover differences in how indigenous Minang and Javanese transmigrant farmers view 21 important concepts, including soil, rice, water, vegetables and fertilizer.

The relative distance between such concepts can suggest how settlers vary in their approach to work. For instance, one group viewed a close association of men to vegetables, while another viewed vegetables as a women's crop. The Javanese perceive a significantly closer relationship between soil and water than do the Minang. This suggests that collaborative experiments on soil and water might best be undertaken with the transmigrants than the indigenous people.

The proximity of rice and rubber to the Minang, relative to other crops, suggests that these two crops would be good for agricultural experimentation among that group. In contrast, the distance of rubber from the Javanese, relative to other crops, suggests that rubber might not be a good crop to use in collaborative work with them.

With respect to fertilizers, the transmigrants' had significantly different views than the indigenous population. The necessity for the transmigrants to gain a livelihood from very small land-holdings on overcrowded Java made fertilizer use important. Also, transmigrants have had more exposure to agricultural extension efforts on fertilizer usage than the indigenous people.

The researchers point out that such patterns in the cognitive maps are closely correlated with patterns in farming. And, by using the results of such studies, scientists and extension workers can more effectively match farming systems and new agricultural technology to the people who use them. *University of Hawaii.*

Organic matter important in farming systems

A marked response of some crops to mulch and green manure suggests that, properly managed, organic matter may temporarily reduce the need for lime and fertilizers. In several experiments, TropSoils scientists have quantified the influence of green manures on crop yields, evaluated tree and herbaceous legumes for use on transmigrant farms, and incorporated information from transmigrants into the selection and design of green-manuring systems.

Two leguminous tree species, *Albizia falcataria* and *Calliandra calothyrsus*, show potential for use in alley cropping in the acid, infertile soils and the warm, humid climate of the research site in Indonesia. Upland rice did not respond significantly to organic-matter additions, but cowpea crop yields were increased by addition of *Albizia* prunings.

These results indicate that alley cropping provides only a marginal benefit to farmers during the first year. However, as the tree pruning and cropping sequence continues, some improvement in soil fertility and crop yields may occur. Also, the hedges of trees can provide other benefits, including animal forage, fuel and erosion control.

Of the technologies tested, alley cropping with *Albizia* seems to hold the most promise, and should be tested on the farm. If such methods for managing organic matter prove practical, farmers with limited resources may be able to improve yields without increasing their outlay for lime. *University of Hawaii.*

Mycorrhizae enhance growth of pasture legumes

TropSoils scientists have found that inoculations of VA mycorrhizal fungi boost the growth of legume forage plants in acid soils. The scientists examined the effects of liming, phosphorus fertilization and VA mycorrhizae on plant growth in a soil with a toxic level of aluminum, and found that mycorrhizal inoculation improved growth responses of two species of *Desmodium*, demonstrating that both are highly mycorrhizal dependent.

Mycorrhizal associations apparently helped alleviate phosphorus deficiency, which is especially significant because the *Desmodium* species tested are typically grown on phosphorus-fixing soils. The results also show, however, that plant tolerance to toxic elements in acidic soils may not be improved by colonization with mycorrhizae.

These results further illustrate the fact that establishing plants in acid tropical soils is difficult unless mycorrhizal plants, fertilization and liming are matched to the specific acid soil infertility complex. *University of Hawaii.*

Simulation models predict crop's performance

TropSoils scientists are developing numerical models that can help guide the management of crops on acid soils in the humid tropics. Properly formulated, such models can predict a crop's performance across broad geographic and climatic regions, accelerating the progress of agricultural research and development.

The researchers have identified the minimum soil, crop and weather data needed, and have used this data set to test and adapt existing models. After careful calibration, the models have been used to predict the performance of rice and maize cultivars, and to test and screen varieties. The models will also be applied to soybean and peanut.

Results show that models can simulate and predict dates of plant emergence, panicle initiation and physiological maturity. They are sensitive to day length, and can be applied to any location where maximum and minimum air temperature and solar radiation data are available.

These models have several practical applications. For instance, results from simulated and actual maize crops in West Sumatra confirm that subsoil acidity rather than low rainfall is the major constraint to corn production during the dry season. Also, the models can accurately predict rates of rice development in regions where the rates vary with altitude and climate, reducing the need for trial-and error field experiments. *University of Hawaii.*

Expert systems help spread knowledge of soils

TropSoils is using advanced computer programs called expert systems to capture not only the factual knowledge of experts but some of their problem-solving skill as well. A prototype expert system designed for use in liming acid soils is being tested and will soon be distributed to some 100 sites in the tropics.

Using an expert system running on a microcomputer, people with limited training can access knowledge and insight gained from decades of experience. TropSoils researchers evaluate a wide range of information for use in their expert systems, including facts and rules of thumb acquired from farmers.

Expert systems are especially useful for solving the highly complex and varied problems found in soil management, which must take into account soils, plants, climates and human behavior. While most soil-management recommendations must be site-specific, conditions in one region are often analogous to those in another. By applying such analogues, expert systems speed the transfer of technology from region to region. *University of Hawaii.*

Alley-cropping may reduce need for lime

Proper management of organic material may reduce the need for lime and fertilizers on small farms in the humid tropics. Two leguminous tree species, *Albizia falcataria* and *Calliandra calothyrsus*, show potential for use in alley-cropping on acid soils and under warm, humid conditions at the research site in Indonesia. Of the procedures tested, alley-cropping with *Albizia* seems to hold the most promise for reducing lime requirements, and is ready for testing by farmers.

Alley-cropping helped some crops more than others. Cowpea yields increased with the addition of *Albizia* prunings, but upland rice yields did not respond significantly.

Results indicate that alley-cropping provides a slight benefit to farmers during the first year. As the tree-pruning and cropping sequence continues, some improvement in soil fertility and crop yields may occur. The hedges also provide forage, fuelwood and erosion control. *University of Hawaii..*

'Low-input'—a first step to permanent cropping

TropSoils scientists have developed a low-input cropping system that could help farmers progress from shifting cultivation to permanent agriculture on acid soils in the humid tropics.

Shifting cultivation has been blamed for much of the destruction of tropical forests. Scientists estimate that properly managing a single acre of permanent cropland prevents the need for clearing five acres of rainforest per year.

The low-input cropping system includes a kudzu fallow, a rotation of acid-tolerant rice and cowpea cultivars, crop-residue return, chemical control of weeds and pests, and the use of small amounts of fertilizers.

While low-input cropping is considered transitory, an experimental low-input system at Yurimaguas, Peru has remained productive much longer than expected. Seven continuous crops in three years have yielded a total of 13.8 tons per hectare of rice and cowpea grain. Purchased chemical inputs account for only 8% of total production costs. Removing only the grains produces very high nutrient recycling values of main elements except for phosphorus. *North Carolina State University.*

Continuous cropping sustains soil resources

Long-term experiments have shown that continuous cultivation of food crops can succeed in acid soils of the humid tropics. Results also suggest that well-managed continuous cropping will tend to sustain, not deplete, the world's soil resources, because the system's high productivity makes commercial farming feasible and decreases the pressure to clear new lands.

Altogether, 36 crops of corn, rice, soybeans or peanuts have been harvested during 15 years in a long-term experiment at Yurimaguas, Peru. In Manaus, Brazil, 13 crops of a corn-soybean rotation have been harvested during six years. Yields are high and reasonably stable. Soil properties have improved with continuous cultivation, as calcium and magnesium have moved into the subsoil, reducing acidity.

Because the system's stability depends on high-value crops and the judicious use of lime and fertilizers, it is only applicable to areas where there are adequate markets, roads and sources of credit. *North Carolina State University.*

José Benites with soil samples from long-term studies at Yurimaguas Peru.

Improved fallows restore field productivity

Selected high-biomass, nitrogen-fixing plants can restore productivity to abandoned fields more rapidly than can unmanaged forest fallows, according to the results of TropSoils research in the humid tropics. The findings are important because unmanaged fallows restore productivity very slowly, and much of the land available to shifting cultivators lies idle each year. In addition, the pressure for cropland has forced farmers in some areas to cut fallows short, with a subsequent loss in food-crop production.

While the studies are still under way, several conclusions can be drawn about the use of improved fallows:

- Soil physical properties improve with time under fallows.
- Levels of available nutrients in the topsoil decrease with time, probably because they are taken up and stored in the biomass.
- After 16 months of growth, total biomass accumulation is highest in the bush or tree fallows and lowest in the spreading types.
- An almost complete ground cover was established within four to eight months.
- Weed control in all planted fallows is better than the natural forest fallow. Control is quickest and most effective with the spreading fallow types. *North Carolina State University.*

Technology boosts paddy rice production

Technology for sustained irrigated rice production in fertile alluvial soils of the Amazon has been validated and is now being transferred to producers through extension programs. Several general principles of Amazon flooded-rice production have been established, including:

- Two crops a year with recommended short-statured varieties can produce annual yields of 12 to 15 ton/ha.
- Fertilization requirements are minimal.
- Land can be cleared by slash and burn or by bulldozing, since soil compaction from bulldozing does not seriously affect paddy rice.
- Supplemental irrigation every two weeks increases yields by about 50% above crops dependent on rainfall.
- Transplanting affords higher yields than broadcasting for the first two crops; after this, the paddies are sufficiently level for seeding.

Considering that one hectare of acid soils must be cleared every year to produce one ton of upland rice, every hectare under irrigated rice production could eliminate the need for clearing 12 to 15 hectares of tropical forest annually. *North Carolina State University.*

Legume-based pastures improve productivity

Long-term studies indicate that several types of improved, legume-based pastures could help sustain beef and milk production while conserving soil resources in the humid tropics of Latin America. When they are properly managed, legume-based pastures protect the soil, require relatively few cash inputs, make good use of soils unsuitable for food crops, and produce milk and meat with grazing animals, which recycle most of the nutrients they consume.

Poorly managed pastures are an economic and ecological liability. Use of pasture species badly adapted to tropical soils and environments leads to poor animal nutrition and low productivity. Several million hectares of rainforest have been cleared for pastures, only to be abandoned as the pastures become degraded by overgrazing, soil compaction and erosion.

TropSoils research indicates that high animal production can be sustained, with low inputs, using three widely differing pastures in acid upland soils. These pastures are a mixture of two stoloniferous grass and legume species (*Brachiaria humidicola/Desmodium ovalifolium*), or a mixture of two erect grass and legume species (*Andropogon gayanus/Stylosanthes guianensis*), or one pure legume pasture of *Centrosema pubescens*.

After four to six years of continuous grazing, soil physical properties remained good and chemical properties improved, because more than 80% of the nutrients applied as fertilizer was recycled to the soil. Studies suggest that the nitrogen contribution of legumes to the associated grass under grazing in highly acid soil is equal to 150 kg of urea nitrogen. *North Carolina State University.*

Degraded steeplands can be reclaimed

New techniques may help reclaim several million hectares of degraded, unproductive pasture in the Amazon. By managing tillage and species selection, scientists are finding ways to increase ground cover and reduce erosion in areas of steep slopes and high rainfall.

Of the species studied, grasses are readily established without tillage, while legumes require at least minimum tillage. The stoloniferous grass species rapidly cover new areas and compete strongly with species already present.

Centrosema grows faster and is more aggressive than *Desmodium ovalifolium*.. After six months of grazing, the percentage of grasses increased, while the percentage of legumes decreased.

In abandoned crop fields with sparse ground cover and extensive erosion, a simple reclamation procedure was developed: remaining vegetation was slashed and burned, 22 kg of phosphorus per hectare was broadcast, and seeds of *Desmodium ovalifolium* or *D. heterophyllum* were broadcast. Within three to six months, when a complete ground cover is established, farmers can choose to plant acid-tolerant tree species such as coffee or achiote. This practice is successful on slopes of 30 percent or greater. *North Carolina State University.*

Lands compacted by bulldozers can be improved

Much farm land in the humid tropics has been mechanically cleared of forest in ways that remove topsoil, compact the subsoil, and promote erosion. Frequently such fields are soon abandoned because crops fail. TropSoils investigations conducted in the Sitiung transmigration settlements of West Sumatra, Indonesia, have resulted in methods for reclaiming degraded soils for continuous cultivation.

The practices studied were tillage and the application of lime and fertilizer. Tillage proved effective only when accompanied by chemical inputs. As the rate of chemical input increased, so did yields, although rice did not respond to high fertility as strongly as did soybean.

Green manure contributed substantially to increasing yields of all crops. Mulching was effective primarily during periods of moderate drought. Deep tillage and strip forking was somewhat beneficial for soybean but did not increase rice yields. In contrast, rototilling was good for rice but only slightly improved soybean yield. *North Carolina State University.*

Land cleared by bulldozers in the transmigration settlements of Indonesia.

Is alley-cropping suitable for acid soils?

In areas with increasing demographic pressure, traditional forms of shifting cultivation must be supplanted by production systems that yield more food on the available land. TropSoils scientists are trying to determine the potential of alley-cropping on the acid soils of Latin America and Southeast Asia. Previous research indicates that alley-cropping, the combination of rows of leguminous trees with annual crops grown between them, has been relatively successful on the more fertile soils of West Africa.

Prunings from the trees form a mulch that may aid in weed control and provide nitrogen and other nutrients, cycled from deep in the soil, to the crops. The use of such organic additions may prolong the productivity of the acid, infertile soils found in much of the humid tropics.

A study was conducted to assess the suitability of various leguminous trees or shrubs in an alley-cropping system, to study changes in soil chemical properties and how they are affected by the amount of prunings added, and to measure the effects of pruning additions on crop yields and yield stability.

Of the six original leguminous trees or shrubs assayed, four have been eliminated due to poor survival or to unsuitability. Two of them, *Inga edulis* and *Erythrina*, appear to have good survival and coppicing ability, and biomass production is high. The effects on crop yields and sustainability have been mixed. The real test for alley-cropping on acid soils will be if there are enough nutrients in the subsoil to recycle for sustained production. *North Carolina State University.*

Larry Szott of N.C. State University, examining the site of an alley-cropping experiment at Yurimaguas, Peru.

Countries use system of classifying soils for management

A system of classifying soils based on factors that directly affect their crop-production potential is receiving world-wide attention and extensive application. To date, 34 countries and eight international organizations are using the Fertility Capability Classification (FCC) in agricultural research and development.

The FCC system focuses on the upper portion of the soil where plant root activity is greatest and management practices are most influential. Attention is given to those physical and chemical factors within this zone which have a primary influence on responsiveness to management and consequently on plant growth.

Interpretation of FCC for wetland soils for rice production was successfully validated in the Philippines. Applications for conventional cropping systems, low-input systems and agroforestry are being studied. An expert system is being developed and drafts are available in English, Spanish, Portuguese, French and Indonesian.

The Food and Agriculture Organization has applied FCC to its soil classification for Africa, which provides an inventory of soils characterized by their productive potential. IBSRAM through its various networks is developing a crop-specific classification system based on soil characteristics defined in the FCC. *North Carolina State University.*

Network links projects in Latin America

Scientists in eight Latin American countries have joined a collaborative research network whose goal is to improve the management of tropical soils. The network, called RISTROP (*Red de Investigacion de Suelos Tropicales*), is spreading new soil-management technologies beyond the primary TropSoils site in Yurimaguas, Peru.

Experiments planned during a 1986 workshop in Yurimaguas will provide useful feedback to the network and to TropSoils. Each participant in the network is supported by the host country institutions. TropSoils provides assistance for coordination, for the selection and characterization of research sites, for analysis and interpretation of data, and for the exchange of information among collaborators.

Support for the network has centered on technical visits by TropSoils personnel to participating institutions during implementation of field experiments. In addition to assisting in adjusting methodologies to local conditions, these visits have provided TropSoils an opportunity to become familiar with the research programs of the national institutions. *North Carolina State University.*

New methods can restore productivity to acid soils

New procedures may overcome soil fertility constraints in a transmigration area of West Sumatra. In this region large-scale bulldozer clearing of a primary tropical rainforest has adversely affected soil productivity.

While the soils have favorable granular structure, they are quite acid, have toxic levels of aluminum, and have low levels of essential nutrients. A strategy based on previous humid tropical experience was devised to make sustained production of basic food crops in this area technically possible.

Results indicate that reclamation of soils damaged by mechanical land clearing is feasible. Applying lime and fertilizers is essential to reclaiming unproductive land and maintaining soil productivity. Recommendations can be made according to soil tests for specific crop rotations. The use of organic matter, particularly crop residues and green manures, can help decrease lime, fertilizer and weed-control requirements. *North Carolina State University; University of Hawaii..*

Workshop stimulates technology transfer

TropSoils research has begun to yield results ready for use in developing nations. To help disseminate this information, TropSoils conducted a 21-day workshop on tropical soils management at its primary research site in Yurimaguas, Peru.

The purpose of the program was to acquaint working Latin American scientists with the most recent concepts in tropical soil management, to identify common interests, and to establish a soil research network. The 31 participants represented 23 potential research sites within 15 national institutions in ten different countries.

The workshop fostered a greater awareness of the on-going research by TropSoils, and plans for collaborative research with TropSoils by the participating countries were developed. Scientists from the ten representative countries shared their knowledge and understanding of the state-of-the-art in soil management. A network was formed among participants in Latin America to address common problems and to share information and experiences. *North Carolina State University.*

Model accurately calculates water loss from cropped soils

A model has been developed for calculating soil evaporation and crop transpiration separately for a row crop with an incomplete canopy cover. In semiarid climates, such as those in West Africa, a large portion of the soil surface, mostly between rows of crops, is uncovered. Both the soil surface and the crop canopy are involved in water loss from the soil.

A study was undertaken to mechanistically simulate water loss for a row crop with an incomplete canopy cover from standard weather data, and soil and crop properties. A proposed model was tested by comparing measured and predicted values of soil evaporation and crop evapotranspiration.

This model should be a useful tool in analyzing various irrigation and crop management systems in water-limited areas. It also will aid in the design and analysis of field experiments on water-use efficiency. *Texas A&M University.*

The hot, dry winds of sub-Saharan Africa quickly rob moisture from crops and soils.

Studies seek ways to make the most of scarce rainfall

TropSoils research has gathered information that may help farmers in Sahelian Africa reduce the risk of crop failure due to drought. Because rainfall in the Sahel is scarce and irregular, farmers must try and plant when and where the odds for rain are in their favor. TropSoils research has attempted to improve their success rate by calculating rainfall probabilities by date and region, and by learning how to manage crops and soils to take advantage of whatever moisture is available. So far, the studies have—

- quantified temporal variation and distribution, overall trends and periodicities, patterns of wet and dry spells of rainfall, and length of the growing season;
- measured the physical and hydrological properties of major cropped soils in Niger, quantifying moisture loss patterns and rain-use efficiency;
- estimated evapotranspiration of economically important crops from climatic data.

The results can help predict the reliability of rains during the growing season for many locations in Niger. They can also be used by plant breeders, who must adapt crops to the growing conditions. *Texas A&M University.*

Rainfall harvesting increases crop yields in semiarid area

Rainfall harvesting has potential for increasing grain yield in regions with limited rainfall and sandy soils. In semiarid regions cereals are often sown before the start of the rains. If rainfall is less than required for germination, crop stands are spotty, replanting is necessary, and yields may be adversely affected. Rainfall-harvesting techniques exhibit advantages by reducing evaporation loss and weed growth, and by increasing water conservation.

A study was undertaken to determine the potential of contour strip rainfall harvesting (CSRH) for cereal production in three main agroclimatic regions of sandy soils in Niger, and to evaluate the influence of fertilization and plant density on the harvesting systems.

Results show significant positive effects due to water management. The CSRH technique induced a deeper rooting system and dramatically increased dry matter production. Increases in grain yields ranged from 56% to 120%. Nitrogen and phosphorus fertilization were necessary to obtain maximum benefits from the rainfall. Higher plant density increased the yield of sorghum but had no effect on millet. *Texas A&M University.*

Soil fertility and cultivars influence water-use efficiency

TropSoils scientists are finding that both nutrient management and cultivar selection influence a crop's ability to use water efficiently. Nutrient deficiencies, particularly nitrogen and phosphorus, greatly inhibit crop production on semiarid lands in Sahelian Africa. There is also evidence that some cultivars more efficiently utilize nutrients than others.

Crops studied responded to nitrogen and phosphorus, and showed a strong interaction among level of available water, cultivar and soil fertility. These results suggest that soil management practices to increase the amount of available water will be economical only when nitrogen and phosphorus deficiencies are corrected and when responsive genotypes are used. *Texas A&M University.*

Windbreaks improve plant's environment and crop growth

TropSoils scientists have found that neem tree windbreaks provide several benefits to crop growth by modifying the environment. Studies were conducted in the Maggia Valley of Niger, where CARE began planting windbreaks in 1975, in order to determine how windbreaks modify climate and affect cereal growth, and to investigate the influence of wood-harvesting methods on wind protection between the windbreak rows.

Results showed a decrease of 29% to 41% in average wind speed at crop height at the center of the field, compared to that outside the windbreaks. Protection by the windbreak significantly increased dry matter production except near the rows, where it was reduced. Fertilizers increased grain yields regardless of distance from the windward row.

Partial pollarding proved to be the best harvest method for wood with the lowest loss of efficiency. While this may not yield as much total wood as other techniques, harvesting can be done while maintaining a reduction in wind speeds greater than 30% between the rows. *Texas A&M University.*

Mulching improves degraded Sahelian soils

Several procedures for reestablishing vegetation in the Guesselbodi Forest near Niamey, Niger, were conducted in cooperation with the Forest Land Use Project. The simplest method studied, mulching with tree branches, was more effective than tillage in the reestablishment of vegetation on barren forest soils.

These findings have important consequences for soil conservation in the Sahel, where the pressures of increasing population and the demand for forage and fuel have led to serious degradation of forests. Tree branches, a waste product of commercial firewood harvesting, are readily available in areas being harvested and are easily placed on the surface of barren forest soils. *Texas A&M University.*

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Personnel engaged in degree-related programs supported by TropSoils and collaborators. September, 1981—December, 1986.

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Personnel in degree-related programs

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*Degree programs at collaborating universities **(Continued next page)**

North Carolina State University (Continued).

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Wade, Mike, NCSU, Indonesia	1983-1986
Santoso, Djoko, CSR, Indonesia	1983-1984
Sukmana, Soleh, CSR, Indonesia	1984-1986
Guyton, Ronald, UH, Indonesia	1986-1986
Arya, Lalit, UH, Indonesia	1986-1986
Bandy, Dale, NCSU, Peru	1981-1982
Benites, Jose, NCSU, Peru	1982-1986
Alegre, Julio, NCSU, Peru	1985-1986
McCollum, Robert, NCSU, Peru	1982-1985
Villavicencio, Manuel, INIPA, Peru	1981-1986
Del Castillo, Dennis, NCSU, Peru	1983-1986
Chase, Robert, TAMU, Niger	1983-1985
Persaud, Naraine, TAMU, Niger	1984-1986

Personnel engaged in the Cornell University component

Name	Position	Specialty	Affiliation
Boaventura, Afonso	Researcher	Fertility	EMBRAPA
Bouldin, David	Senior Scientist	Fertility	CU
Bowen, Walter	Senior Scientist	Fertility	CU
Bryant, Ray	Senior Scientist	Pedology	CU
Burle, Marilia	Researcher	Fertility	CU
Buttler, Imo	Junior Scientist	Fertility/Model	CU
Cardoso, Irene	Researcher	Management	EMBRAPA
Carsky, Robert	Junior Scientist	Fertility	CU
Carvalho, Luiz	Junior Scientist	Plant Physio.	EMBRAPA
Costa, Francisco	Junior Scientist	Fertility	CU
Cox, Fred	Senior Scientist	Fertility	NCSU
Duxbury, John	Senior Scientist	Organic Matter	CU
Freitas, Elias	Senior Scientist	Soil Physics	EMBRAPA
Goedert, Wenceslau	Administrator	Administration	EMBRAPA
Grove, Thurman	Senior Scientist	Management	CU
Gustafson, Daniel	Senior Scientist	Coordination	IICA
Helman, Howard	Agri. Devlp. Off.	Administration	USAID
Klausner, Stuart	Senior Scientist	Soil Management	CU
Kornelius, Euclides	Senior Scientist	Pastures	CPAC
Lathwell, Douglas	Program Coord.	Coord./Res.	CU
Lins, Ibere	Junior Scientist	Fertility	NCSU
Lobato, Edson	Senior Scientist	Soil Fertility	EMBRAPA
Lucey, Robert	Administrator	Administration	CU
Luchiari, Ariovaldo	Junior Scientist	Agrometerology	EMBRAPA
Lusk, Howard	Agri. Devlp. Off.	Administration	USAID
Macedo, Jamil	Junior Scientist	Pedology	EMBRAPA
Marcano-Martinez, E.	Junior Scientist	Soil Chemistry	CU
McBride, Murray	Senior Scientist	Chemistry	CU
McVoy, Christopher	Junior Scientist	Physics	CU
Mendes, Cristina	Researcher	Plant Ecology	CNPQ
Metz, Joe	Administrator	Administration	CU
Miranda, Leo	Senior Scientist	Soil Fertility	EMBRAPA
Motavalli, Peter	Junior Scientist	Fertility	CU
Nicholaides, John	Senior Scientist	Fertility	NCSU
Osmond, Deanna	Junior Scientist	Management	CU
Oyer, Edwin	Administrator	Administration	CU
Pereira, Joao	Senior Scientist	Soil Fertility	EMBRAPA
Peres, Jose	Senior Scientist	Soil Microbio.	EMBRAPA
Pontes, Raimundo	Administrator	Administration	EMBRAPA
Quintana, Jorge	Junior Scientist	Fertility	CU

Name	Position	Specialty	Affiliation
Ranzani, Guido	Administrator	Administration	EMBRAPA
Reid, Shaw	Senior Scientist	Management	CU
Reis, Eduardo	Senior Scientist	Irrigation	CPAC
Resck, Dimas	Senior Scientist	Soil Management	EMBRAPA
Ritchey, Dale	Senior Scientist	Management	CU
Riha, Susan	Senior Scientist	Physics	CU
Rodrigues, Gustavo	Senior Scientist	Plant Physio.	EMBRAPA
Snyder, Victor	Senior Scientist	Management	CU
Sousa, Djalma	Senior Scientist	Soil Chemistry	EMBRAPA
Stoner, Eric	Senior Scientist	Management	CU
Suhet, Allert	Senior Scientist	Microbiology	EMBRAPA
Taylor, Sam	Agri. Devlp. Off.	Administration	USAID
Van Wambeke, Armand	Senior Scientist	Pedology	CU
Vilela, Lorival	Senior Scientist	Soil Fertility	EMBRAPA
Wagenet, Jeff	Senior Scientist	Physics	CU
Wagner, Elmar	Administrator	Administration	EMBRAPA
Wondergem, Abraham	Researcher	Fertility	UW

Personnel engaged in the University of Hawaii component

Name	Position	Specialty	Affiliation
Agus, Fahmuddin	Researcher	Conservation	CSR
Agus, Herman	Researcher	Sociology	AU
Aluisius, Djohan	Junior Scientist	Physics	UH/AU
Arya, Lalit	Senior Scientist	Physics	UH
Cassel, Keith	Senior Scientist	Physics	NCSU
Chapman, Barbara	Senior Scientist	Sociology	UH
Chu, Ada	Researcher	Chemistry	UH
Cobb, Richard	Agri. Officer	Administration	USAID
Colfer, Carol	Senior Scientist	Anthropology	UH
Demb, Ada	Administrator	Administration	UH
Dierolf, Tom	Junior Scientist	Fertility	UH
Dudley, Richard	Senior Scientist	Fisheries	UH
El-Swaify, Samir	Senior Scientist	Conservation	UH
Evensen, Carl	Junior Scientist	Fertility	UH
Evensen, Stacy	Junior Scientist	Nutrition	UH
Evi, Martha	Junior Scientist	Sociology	AU
Gill, Dan	Junior Scientist	Fertility	NCSU
Godwin, Douglas	Senior Scientist	Modeling	IFDC
Guyton, Ronald	Senior Scientist	Management	UH
Hale, Joanne	Agri. Officer	Administration	USAID
Hansen, James	Junior Scientist	Chemistry	UH
Herwasona, Soedgito	Senior Scientist	Botany	HB
Hidayat, Endang	Junior Scientist	Fertility	CSR
Huang, Ruey	Graduate Assistant	Biochemistry	UH
Hue, Nguyen	Senior Scientist	Chemistry	UH
Hurdus, Alan	Agri. Officer	Administration	USAiD
Istiglal, Amien	Junior Scientist	Fertility	CSR/UH
Itoga, Stephen	Senior Scientist	Info. Science	UH
Kamprath, Eugene	Senior Scientist	Fertility	NCSU
Kanehiro, Yoshinori	Senior Scientist	Chemistry	UH
Kan, Stephenie	Junior Scientist	Agr. Economics	UF
Khairul	Admin. Assistant	Administration	UH/CSR
Kilham, Phoebe	Junior Scientist	Geog. Info. Sys.	UH
Legowo, Eko	Junior Scientist	Physics	UH
Li, Zhi Cheng	Junior Scientist	Expert Systems	UH
Li. , Li-Ling	Junior Scientist	Modeling	UH
McArthur, Harold	Senior Scientist	Anthropology	UH
Mochtar, Naim	Senior Scientist	Sociology	AU
Muljadi, D.	Administrator	Administration	CSR
Murabayashi, Naomi	Secretary	Administration	UH

Name	Position	Specialty	Affiliation
Ndiaye, Jean-Pierre	Junior Scientist	Fertility	UH
Newton, Barbara	Senior Scientist	Sociology	UH
Rauch, Marian	Senior Scientist	Human Resources	UH
Sakumoto, Suemi	Fiscal Acc'ting	Administration	UH
Santoso, Djoko	Senior Scientist	Fertility	CSR
Santoso, Edi	Junior Scientist	Fertility	CSR
Schultz, Janet	Junior Scientist	Conservation	UH
Sharpley, Andrew	Senior Scientist	Modeling	ARS
Sholeh, Ir.	Senior Scientist	Management	CSR
Sigman, Vickie	Senior Scientist	Sociology	UH
Silva, James	Senior Scientist	Fertility	UH
Singh, Upendra	Junior Scientist	Modeling	UH
Smith, M. Ray	Administrator	Administration	UH
Soekardi, M.	Junior Scientist	Sci. Pedology	CSR
Sudjadi, M.	Administrator	Administration	CSR
Sukmana, Soleh	Senior Scientist	Physics	CSR
Suwardjo,	Senior Scientist	Conservation	CSR
Tajeb, Mocharam	Agri. Officer	Administration	USAID
Tang, Chung-Shih	Senior Scientist	Biochemistry	UH
Tappan, Walter	Agri. Officer	Administration	USAID
Thompson, John	Senior Scientist	Management	UH
Trangmar, Bruce	Junior Scientist	Geomorphology	UH
Tsuji, Gordon	Project Manager	Administration	UH
Tuivavalagi, Nacanieli	Junior Scientist	Fertility	UH
Uehara, Goro	Program Coord.	Admin./Res.	UH
Wade, Mike	Senior Scientist	Fertility	NCSU
Widjaja-Adhi, I.P.G.	Senior Scientist	Fertility	CSR
Wilson, Kathleen	Senior Scientist	Human Dev.	UH
Yost, Russell	Senior Scientist	Fertility	UH

Participants in the North Carolina State University component

Name	Position	Specialty	Affiliation
Acuna, E.	Researcher	Pastures	INIPA
Adiningsih, Sri	Division Head	Administration	CSR
Agus, Fahmuddin	Researcher	Physics	CSR
Al-Jabri	Researcher	Fertility	CSR
Alegre, Julio	Senior Scientist	Physics	NCSU
Alvarado, Alfredo	Junior Scientist	Classification	NCSU
Ara, Miguel	Junior Scientist	Pastures	NCSU
Arca, Manuel	Director	Administration	INIPA
Arevalo, Luis	Researcher	Fertility	INIPA
Ayarza, Miguel	Junior Scientist	Pastures	CIAT
Ayre, Olinda	Technician	Laboratory	NCSU
Aznaran, Andres	Researcher	Tillage	INIPA
Bandy, Dale	Senior Scientist	Administration	NCSU
Bastos, Joaquim	Senior Scientist	Fertility	EMBRAPA
Bathrick, David	Agricultural Off.	Administration	USAID
Benavides, Julio	Station Director	Administration	INIPA
Benites, Jose	Senior Scientist	Management	NCSU
Buol, Stanley	Senior Scientist	Classification	NCSU
Bustamante, Miguel	Coordinator	Training	INIPA
Calderon, Mario	Researcher	Pastures	CIAT
Cantera, G.	Researcher	Pastures	INIPA
Cassel, Keith	Senior Scientist	Physics	NCSU
Castilla, Carlos	Junior Scientist	Pastures	CIAT
Ceballos, Jorge	Program Manager	Administration	INIPA
Colfer, Carol	Senior Scientist	Anthropology	UH
Correa, Jose	Researcher	Soil Physics	EMBRAPA
Couto, Walter	Senior Scientist	Classification	NCSU
Cox, Fred	Senior Scientist	Fertility	NCSU
Cravo, Manoel	Senior Scientist	Fertility	EMBRAPA
Davelouis, Jose	Junior Scientist	Fertility	UNA
Davey, Charles	Senior Scientist	Agroforestry	NCSU
Del Aguila, Graciela	Admin. Assistant	Administration	NCSU
Del Castillo, Dennis	Senior Scientist	Management	NCSU
de Moraes, Erci	Station Director	Administration	EMBRAPA
Dextre, Rolando	Junior Scientist	Pastures	INIPA
Eisenbeer, Helmut	Junior Scientist	Physics	NCSU
Escobar, Ricardo	Researcher	Agroforestry	IICA
Escobar, Mercedes	Senior Scientist	Economics	INIPA
Fernandes, Erick	Junior Scientist	Agroforestry	NCSU
Flores, Miguel	Researcher	Pastures	INIPA

Name	Position	Specialty	Affiliation
Florindez, Sue	Admin. Assistant	Administration	NCSU
Fontes, Marisa	Junior Scientist	Chemistry	NCSU
Forbes, Tonya	Technician	Laboratory	NCSU
Fuigueroa, Jorge	Researcher	Pastures	INIPA
Gallo, Marta	Researcher	Pastures	INIPA
Galvao, Expedito	Researcher	Rice Breeding	EMBRAPA
Galvez, Marco	Researcher	Weed Control	INIPA
Gedger, Putu	Country Coord.	Management	CSR
Gichuru, Mwenja	Junior Scientist	Fertility	NCSU
Gill, Dan	Junior Scientist	Fertility	NCSU
Goedert, Wenceslau	Director	Administration	EMBRAPA
Gonzalez, Mariela	Admin. Assistant	Administration	NCSU
Gowland, Patricia	Technician	Laboratory	NCSU
Guillen, Wilfredo	Researcher	Grain Legumes	INIPA
Heryadi, M.	Researcher	Fertility	CSR
Hoag, Robert	Junior Scientist	Classification	NCSU
Hooper, Jonathan	Junior Scientist	Classification	NCSU
Ivazeta, Hemilce	Researcher	Pastures	INIPA
Jurado, Adolfo	Program Manager	Administration	USAID
Kamprath, Eugene	Senior Scientist	Fertility	NCSU
Kasno, Antonius	Technician	Fertility	CSR
Katz, Lisa	Junior Scientist	Fertility	NCSU
Lara, Deysi	Researcher	Pastures	INIPA
Latham, Marc	Director	Administration	IBSRAM
Le Marc, Peter	Senior Scientist	Fertility	RU
Lenne, Jill	Senior Scientist	Pastures	CIAT
Lermo, Juan	Researcher	Agronomy	INIPA
Liegel, Leon	Senior Scientist	Agroforestry	USDA
Lins, Ibere	Junior Scientist	Fertility	EMPAER
Lopez, Jonathan	Researcher	Corn & Sorghum	INIPA
Makarim, Karim	Junior Scientist	Physics	CSR
McCollum, Robert	Senior Scientist	Fertility	NCSU
Medeiros, Valeria	Secretary	Administration	NCSU
Melgar, Ricardo	Junior Scientist	Fertility	Argentina
Merino, Jose	Station Director	Administration	INIPA
Mesia, Ruben	Station Director	Management	INIPA
Miller, Robert	Department Head	Administration	NCSU
Miller, Timothy	Program Manager	Administration	USAID
Monar, Bertha	Program Admin.	Administration	NCSU

(Continued next page)

Participants in the North Carolina State University component

(Continued)

Name	Position	Specialty	Affiliation
Mt. Pleasant, Jane	Junior Scientist	Weed Control	NCSU
Muljadi, D.	Director	Administration	CSR
Naderman, George	Senior Scientist	Management	NCSU
Newman, Laurie	Junior Scientist	Classification	NCSU
Ngachie, Victor	Junior Scientist	Fertility	Cameroon
Nicholaides, John	Program Coord.	Coord./Res.	NCSU
Nurena, Marco	Researcher	Management	INIPA
Oliveira, Luiz	Junior Scientist	Fertility	INPA
Pacora, Lander	INIPA Head	Administration	INIPA
Palm, Cheryl	Junior Scientist	Agroforestry	NCSU
Palma, Victor	INIPA Head	Administration	INIPA
Pashanasi, Beto	Researcher	Agroforestry	INIPA
Perez, Jorge	Researcher	Agroforestry	INIPA
Phillips, Elizabeth	Secretary	Administration	NCSU
Piha, Melvyn	Researcher	Fertility	NCSU
Pizarro, Esteban	Senior Scientist	Pastures	CIAT
Quijandria, Benjamin	INIPA Head	Administration	INIPA
Racchumi, Alfredo	Researcher	Upland Rice	INIPA
Reategui, Kenneth	Senior Scientist	Pastures	INIPA
Roman, Rafael	Technician	Laboratory	NCSU
Ruiz, Pedro	Researcher	Microbiology	INIPA
Salazar, Angel	Researcher	Agroforestry	INIPA
Salazar, Eleazar	Junior Scientist	Classification	Venezuela
Sanchez, Pedro	Program Coord.	Coord./Res.	NCSU
Santoso, Djoko	Senior Scientist	Management	CSR
Schaus, Rodolfo	Researcher	Pastures	INIPA
Schnaar, Rob	Researcher	Fertility	Wageningen
Scholes, Mary C.	Senior Scientist	Microbiology	CSIR
Scholes, Robert	Senior Scientist	Ecology	CSIR
Schulze, Loren	ARDO/Lima	Administration	USAID
Silsbee, Dawn	Secretary	Administration	NCSU
Smith, Christopher	Junior Scientist	Classification	NCSU
Smithson, Paul	Technician	Chemistry	NCSU
Smyth, Jot	Senior Scientist	Fertility	NCSU
Subagjo, H.	Researcher	Classification	CSR
Sudjadi, Mohammed	Director	Administration	CSR
Swift, Michael	Senior Scientist	Biology	TSBF
Szott, Lawrence	Junior Scientist	Agroforestry	NCSU

Name	Position	Specialty	Affiliation
Tepe, Cesar	Researcher	Paddy Rice	INIPA
Toledo, Jose	Senior Scientist	Pastures	CIAT
Thompson, John	Senior Scientist	Administration	UH
Ubiera, Amilcar	Junior Scientist	Mineralogy	Dom. Rep.
Uribe, Eduardo	Junior Scientist	Fertility	Colombia
Valverde, Carlos	Administration	Administration	INIPA
Vela, Jorge	Researcher	Pastures	INIPA
Villachica, Hugo	Senior Scientist	Administration	INIPA
Villavicencio, M.	Station Director	Administration	INIPA
Wade, Michael	Senior Scientist	Fertility	NCSU
Wagner, Elmar	Director	Administration	EMBRAPA
Wegena, Putu	Researcher	Fertility	CSR
Zuniga, Luis	Researcher	Physics	INIPA

Personnel engaged in the Texas A&M University component

Name	Position	Specialty	Affiliation
Adoulaye, Adam	Senior Scientist	Statistics	INRAN
Alfari, I.	Senior Scientist	Comp. Science	DMN
Bationo, Andre	Senior Scientist	Fertility	IFDC
Bloodworth, Morris	Department Head	Administration	TAMU
Boudouresque, Eric	Junior Scientist	Management	UOA
Bronson, Roy	Leader	Administration	NCRP
Bui, Elizabeth	Junior Scientist	Classification	TAMU
Calhoun, Frank	Program Coord.	Coord./Classif.	TAMU
Cardwell, Suzanne	Assist. Adm.	Administration	TAMRF
Chase, Robert	Senior Scientist	Physics	TAMU
Clark, John	Leader	Administration	NCRP
Davis-Rainey, Jessica	Junior Scientist	Management	TAMU
Denneson, Steve	Researcher	Management	CARE
Dicko, Mdm. M.	Researcher	Research	ILCA
Dixon, Joe	Senior Scientist	Mineralogy	TAMU
Doumbia, M.	Junior Scientist	Management	IER
Fuller, Flynn	Agri. Dev. Off.	Administration	USAID
Gandah, Mahamadu	Senior Scientist	Management	INRAN
Garba, Annou	Senior Scientist	Classification	INRAN
Gardiner, James	Junior Scientist	Management	TAMU
Garrett, Steve	Administrator	Administration	TAMRF
Gibbons, Ron	Director	Administration	ICRISAT
Gibson, Ernie	Agri. Dev. Off.	Administration	USAID
Gonda, Jada	Senior Scientist	Plant Breeding	INRAN
Goube, Gaoh	Section Head	Fertility	INRAN
Grayball, Lynn	Agri. Dev. Off.	Administration	USAID
Hallmark, Tom	Senior Scientist	Classification	TAMU
Hatfield, Jerry	Senior Scientist	Cropping Syst.	USDA
Heermans, John	Senior Scientist	Agroforestry	FLUP
Hossner, Lloyd	Program Coord.	Coord./Fertility	TAMU
Ferrari, Kati	Secretary	Administration	TAMU
Jackson, Curtis	Director	Administration	ICRISAT
Jepson, Lance	Agri. Dev. Off.	Administration	USAID
Klaij, Michael	Senior Scientist	Physics	UW
Kouyate, Zoumana	Program Coord.	Coord./Mgt.	IER
Lascano, Robert	Senior Scientist	Physics	TAES
Long, Steve	Junior Scientist	Management	TAMU
Mabry, James	Technician	Research	TAES
Maggio, Robert	Senior Scientist	Remote Sensing	TAMU
Manu, Andrew	Senior Scientist	Laboratory	TAMU

Name	Position	Specialty	Affiliation
McCool, Donald	Senior Scientist	Physics	USDA
Northcut, Gloria	Secretary	Administration	TAMU
Nwanze, Kanayo	Director	Administration	ICRISAT
Oneil, Michael	Researcher	Research	PP
Onken, Arthur	Senior Scientist	Fertility	TAES
Ouattara, Mamadou	Department Head	Administration	INRAN
Oundabar, Botorou	Junior Scientist	Research	INRAN
Parker, Margaret	Secretary	Administration	TAES
Payne, William	Junior Scientist	Management	TAMU
Persaud, Naraine	Senior Scientist	Soil Physics	TAMU
Pfordresher, Ann	Junior Scientist	Classification	TAMU
Piwonka, Norman	Technician	Research	TAES
Puentes, Ruben	Program Manager	Administration	TAMU
Reddy, S.K.	Agri. Dev. Off.	Administration	USAID
Runge, Ed	Department Head	Administration	TAMU
Saley, Moussa	Director Gen.	Administration	INRAN
Serafini, Phil	Senior Scientist	Management	ICRISAT
Shadfan, Harbi	Senior Scientist	Mineralogy	TAMU
Shihadeh, Juanita	Admin. Assistant	Administration	TAMRF
Simpara, Mamadou	Program Coord.	Coord./Mgt.	IER
Soumana, Indrissa	Director Gen.	Administration	INRAN
Sow, Abdoul	Junior Scientist	Management	IER
Steve, Juan	Senior Scientist	Agroforestry	FLUP
Stroosnijder, Leo	Senior Scientist	Physics	WAU
Swindale, Les	Director Gen.	Administration	ICRISAT
Thomas, Wilbur	Agri. Dev. Off.	Administration	USAID
Traore, Fatagoma	Director Gen.	Administration	IER
Upchurch, Dan	Senior Scientist	Cropping Syst.	USDA
Van Bavel, C.	Senior Scientist	Physics	TAMU
Vigil, Rudolph	Agri. Dev. Off.	Administration	USAID
Vollmar, Glen	Director, ME	Administration	INTSORMIL
Wendt, Charles	Senior Scientist	Physics	TAES
Wendt, John	Junior Scientist	Fertility	TAMU
West, Larry	Junior Scientist	Classification	TAMU
Wheaton, Sandra	Asst. Adm.	Administration	TAMRF
Wilding, Larry	Senior Scientist	Classification	TAMU
Yerima, Bernard	Junior Scientist	Classification	TAMU
Zaongo, Christopher	Junior Scientist	Management	TAMU

Collaborators

Organizations and institutions collaborating with Cornell University

Centro de Pesquisa Agropecuaria dos Cerrados– Brazil
Empresa Brasileira de Pesquisa Agropecuaria– Brazil
North Carolina State University– USA
U.S. Agency for International Development– Brazil

Organizations and institutions collaborating with University of Hawaii

Agency for Agricultural Research and Development– Indonesia
Agricultural Research Service, U.S. Department of Agriculture– USA
Andalas University– Indonesia
Center for Soil Research– Indonesia
Institute Pertanian Bogor– Bogor
International Fertilizer Development Center– USA
North Carolina State University– USA
U.S. Agency for International Development– Indonesia

Organizations and institutions collaborating with North Carolina State University

Center for Soils Research– Indonesia
Centro Internacional de Agricultura Tropical– Colombia
Centro de Pesquisa Agropecuria dos Cerrados– Brazil
Cornell University– USA
Empresa Brasileira de Pesquisa Agropecuaria– Brazil
Institute of Development Studies– Finland
Instituto Interamericano de Cooperacion para la Agricultura– Brazil
Instituto Nacional de Investigación y Promoción Agraria– Peru
Instituto Veterinario de Investigación del Trópico y Altura– Peru
International Board for Soil Research and Management– Thailand
National Institute for Amazonian Research– Brazil
Proyecto Especial Pichis-Palcazu– Peru
Reading University– United Kingdom
Tropical Soil Biology and Fertility Program– Zimbabwe
U.S. Agency for International Development– Peru
Unidade de Execucao de Pesquisa de Ambito Estadual de Manaus– Brazil
Universidad Nacional Agraria– Peru
University of Wageningen– The Netherlands
University of Paris– Paris
University of Hawaii– USA
University of Georgia– USA

Collaborators

Organizations and institutions collaborating with Texas A&M University

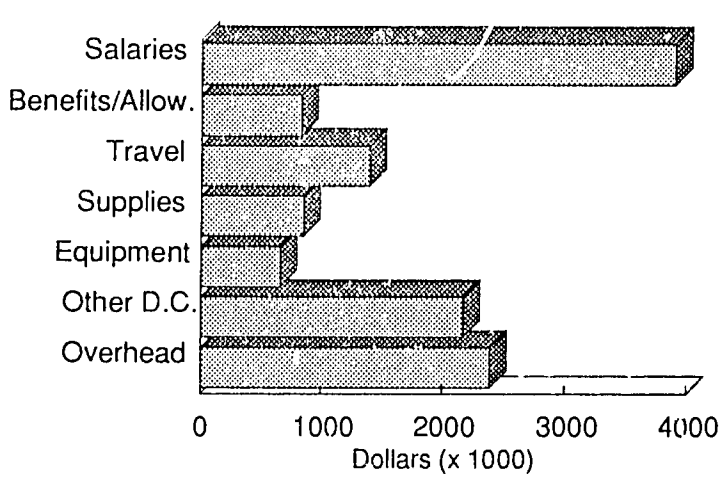
Centre Regional de Formation et D'Application en Agro-meteorologie et Hydrologie– Niger
Collaborative Research Support Program on Sorghum and Millet– USA
Cooperatives for American Relief Everywhere– Niger
Direction de la Meteorologie Nationale– Niger
Forest and Land Use Planning Project– Niger
Institut d'Economie Rural– Mali
Institut Français de Recherche Scientifique et Coopération– France
Institut National de Recherches Agronomiques du Niger– Niger
Institut de Recherches Agronomiques Tropicals– France
International Center for Agricultural Research in the Dry Areas– Syria
International Crops Research Institute for the Semi-Arid Tropics– Niger/Mali
International Fertilizer Development Center– USA
International Livestock Center for Africa– Ethiopia
Niger Cereals Research Project– Niger
Office of International Cooperation and Development– USA
Semi-Arid Food Grain Research and Development– Burkina Faso
Soil Management Support Services– USA
U.S. Agency for International Development– Niger/Mali
U.S. Department of Agriculture– USA
University of Niamey– Niger
University of Wageningen– The Netherlands

Expenditures

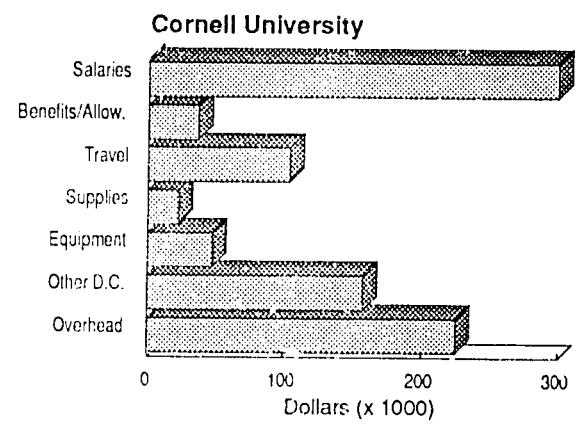
Expenditures of SM-CRSP grant funds by object item and institution, September 1981–December 1986

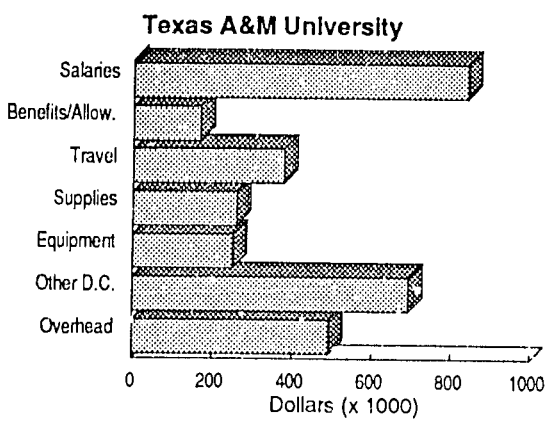
Object	Cornell	Hawaii	NCSU	TAMU	Management Office	Total
Salaries	$299,142	$768,691	$1,566,538	$839,545	$423,921	$3,897,837
Benefits/Allow.	36,447	165,029	381,340	168,523	74,122	825,461
Travel	103,413	294,305	429,327	376,267	193,914	1,397,226
Supplies	22,827	156,563	396,673	259,323	10,497	845,883
Equipment	47,496	133,182	204,433	250,388	22,522	658,021
Other D.C.	157,302	263,809	945,631	692,236	107,230	2,166,208
Overhead	224,644	486,352	861,379	492,916	323,873	2,389,364
Total	**$891,471**	**$2,267,931**	**$4,785,321**	**$3,079,198**	**$1,156,079**	**$12,180,000**

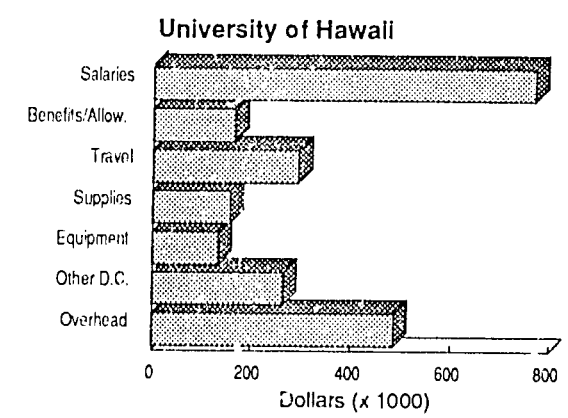
Program-wide expenditures of SM-CRSP grant funds by object item, September 1981–December 1986.

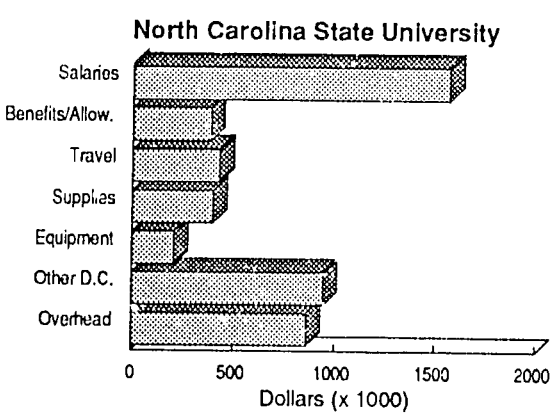


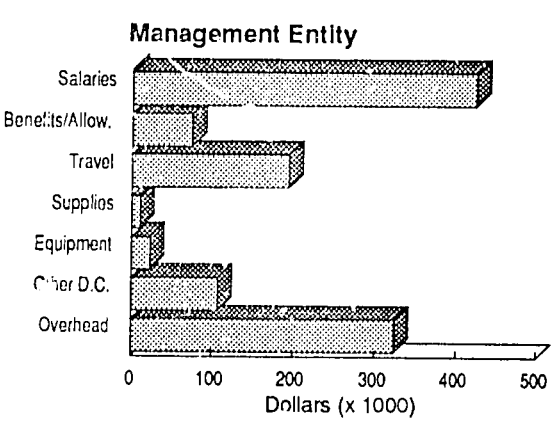
Expenditures by object item for each component, 1981-1986.





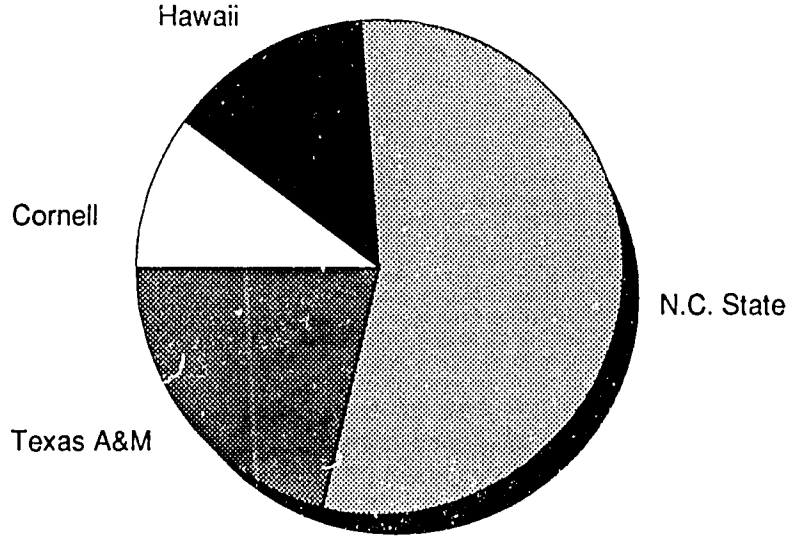






Cost sharing

Cost sharing reported by each university participating in the Soil Management CRSP. September 1981–December 1986.



University	Amount, Dollars
Cornell	342,990
Hawaii	479,676
N.C. State	1,889,102
Texas A&M	721,744
Total	**3,433,512**

Abbreviations

Abbreviation	Name	Country
AARD	Agency for Agricultural Research and Development	Indonesia
AGRHYMET	Centre Regional de Formation et d'Application en Agro-meteorologie et Hydrologie	Niger
AID	Agency for International Development	USA
ARS	Agricultural Research Service (of the USDA)	USA
AU	Andalas University	Indonesia
BIFAD	Board for International Food and Agricultural Development	USA
CARE	Cooperatives for American Relief Everywhere	USA
CEPLAC (CPAC)	Centro de Pesquisa Agropecuaria dos Cerrados	Brazil
CIAT	Centro Internacional de Agricultura Tropical	Colombia
CNPQ	Conselho Nacional de Pesquisa	Brazil
CSIR	Center for Scientific and Industrial Research	South Africa
CSR	Center for Soils Research	Indonesia
CU	Cornell University	USA
DMN	Direction de la Meteorologie Nationale	Niger
EEP	External Evaluation Panel	
EMBRAPA	Empresa Brasileira de Pesquisa Agropecuaria	Brazil
EMPAER	Empresa de Pesquisa, Assistencia Tecnica e Extensao Rural	Brazil
EWC	East-West Center	USA
FERQUIDO	Fertilizantes Quimicos Dominicanos, SA	Dominican Rep.
FLUP	Forest and Land Use Planning Project	Niger
GOV	Government of Venezuela	Venezuela
HB	Herbarium Bogoriense	Indonesia

Abbreviations

Abbreviation	Name	Country
IADS	International Agricultural Development Service	USA
IBSRAM	International Board for Soil Research and Management	Thailand
ICARDA	International Center for Agricultural Research in the Dry Areas	Syria
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics	Niger
IDB	International Development Bank	USA
IDRC	International Development Research Centre	Canada
IDS	Institute of Development Studies	Finland
IER	Institut d'Économie Rurale	Mali
IFDC	International Fertilizer Development Center	USA
IFRSC	Institut Français de Recherche Scientifique et Coopération	France
IICA	Instituto Interamericano de Cooperación para la Agricultura	
ILCA	International Livestock Center for Africa	Ethiopia
INIAA	Instituto Nacional de Investigación Agraria y Agroindustrial	Peru
INIPA	Instituto Nacional de Investigación y Promoción Agraria	Peru
INRAN	Institut National de Recherches Agronomiques du Niger	Niger
INTSORMIL	Collaborative Research Support Program on Sorghum and Millet	USA
IPB	Institute Pertanian Bogor	Indonesia
IRAT	Institut de Recherches Agronomiques Tropicals	France
IVITA	Instituto Veterinario de Investigacion del Tropico y Altura	Peru

Abbreviation	Name	Country
JCARD	Joint Committee on Agricultural Research and Development	USA
JRC	Joint Research Committee	USA
LDC	Less Developed Country	
MUCIA	Midwest Universities Consortium for International Development	USA
NCRP	Niger Cereals Research Project	Niger
NCSU	North Carolina State University	USA
OICD	Office of International Cooperation and Development	USA
PEPP	Proyecto Especial Pichis-Palcazu	Peru
PP	Project Productivite	Niger
PSG	Program Support Grant	USA
RF	Rockefeller Foundation	USA
RU	Reading University	United Kingdom
SAFGRAD	Semi-Arid Food Grain Research and Development	Burkina Faso
SM-CRSP	Soil Management Collaborative Research Support Program	USA
SMSS	Soil Management Support Services	USA
TAES	Texas Agricultural Experiment Station	USA
TAMRF	Texas A & M Research Foundation	USA
TAMU	Texas A & M University	USA
TSBF	Tropical Soil Biology and Fertility Program	Zimbabwe
UCR	University of Costa Rica	Costa Rica
UEPAE	Unidade de Execucao de Pesquisa de Ambito Estadual de Manaus	Brazil
UF	University of Finland	Finland
UFl	University of Florida	USA
UG	University of Georgia	USA
UH	University of Hawaii	USA
UN	University of Niamey	Niger

Abbreviations

Abbreviation	Name	Country
UNA	Universidad Nacional Agraria	Peru
UOA	University of Orleans	France
USAID	United States Agency for International Development	Brazil
USAID	United States Agency for International Development	Indonesia
USAID	United States Agency for International Development	Mali
USAID	United States Agency for International Development	Niger
USAID	United States Agency for International Development	Peru
USDA	United States Department of Agriculture	USA
UW	University of Wageningen	Netherlands

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