



# **UNIVERSITY CONSORTIUM ON SOILS OF THE TROPICS**

## **Annual Report 1973-74**

**The Consortium consists of Cornell University, The University of Hawaii, North Carolina State University, Prairie View A and M University and the University of Puerto Rico.**

**Activities of the Consortium are supported by a grant to the individual units through the Institutional Grants Program, Section 211(d) of the Foreign Assistance Act of 1961 as amended in 1966.**

FOURTH ANNUAL REPORT  
OF THE  
UNIVERSITY CONSORTIUM ON SOILS OF THE TROPICS

July 1, 1973 to June 30, 1974

The Consortium consists of Cornell University, the University of Hawaii, North Carolina State University, Prairie View A&M University, and the University of Puerto Rico.

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## THE CONSORTIUM PROGRAM

This section of the fourth annual report of the University Consortium on Soils of the Tropics describes the background, objectives, accomplishments of the Consortium program as a whole and the utilization of the program in less-developed countries.

By the end of this reporting period, the five institutions had increased their involvement in soils of the tropics substantially. In order to utilize the increased institutional capabilities, the Consortium is now placing more emphasis in utilizing this increased expertise in the characterization and management of tropical soils to assist developing countries.

### A. GENERAL BACKGROUND AND PURPOSE OF THE GRANTS

Soils of the tropics pose unique problems for the development of agriculture. American interests in education and development require knowledge of the applications of soil science in the tropics. The aggregate of American expertise in this area of knowledge is substantial; but it is incomplete, and knowledge of the varied facets of the subject is distributed unequally among American institutions. The grants covered by this report were made to develop a coordinated American resource of knowledge about soils of the tropics and their use.

Institutional grants were made to Cornell University, the University of Hawaii, North Carolina State University, Prairie View A&M University, and the University of Puerto Rico to enhance their capabilities in tropical soils for teaching, research, service, and consultation. The grants were made through the Institutional Grants Program established by Section 211(d) of

the Foreign Assistance Act of 1961 as amended in 1966. The grants were made separately to the several institutions on the basis of their plans for development as centers of knowledge about tropical soils within a Consortium organized to develop complementary coordinated programs.

To implement the joint program, the Consortium plan provides for:

- (a) a council of institutional representatives having administrative authority for policy and for program guidance;
- (b) additional resident and visiting professional staff to reinforce and complement existing competencies;
- (c) support of graduate students and faculty for development of competencies and resources; and
- (d) increase of institutional material resources and supporting staff, including library resources, technicians and stenographic service.

The plan provides for exchanges of personnel to capitalize on the respective strengths of the cooperating institutions, assignments of personnel to tropical areas for experience, and joint cooperative activities for special services.

The cooperating institutions provide administrative services, existing physical resources, inputs from existing faculty competent in the field, and various benefits and services normally provided for other operations. Each is committed to development of viable teaching, research, and utilization programs on soils of the tropics and to accommodate requests for training, technical assistance, and consulting services as feasible and consistent with institutional resources and continuing domestic commitments.

#### B. OBJECTIVES OF THE GRANTS

The five grants were awarded to develop a coordinated American resource of knowledge and professional competence for soils of the tropics

and their use. The objectives of the individual grants vary in detail according to existing institutional competencies and resources and the subject matter areas that need strengthening. Each member institution has defined a field of concentration to be emphasized in the use of grant funds, as follows:

Cornell University: Cultural systems for soils of the tropics.

University of Hawaii: Biology and mineralogy of soils of the tropics.

North Carolina State University: Soil fertility relating plant nutrition to the physical and chemical properties of soils of the tropics.

Prairie View A&M University: Soil fertility problems under savanna-prairie ecology.

University of Puerto Rico: Conservation and protection of soils of the tropics.

### C. ACCOMPLISHMENTS

The accomplishments that are a direct result of AID support are summarized here under the headings: (1) faculty and student involvement; (2) teaching; (3) research; (4) consultation; and (5) library and reference. These areas of activity are treated in the perspective of the Consortium as a whole, including contributing activities of both the individual institutions and joint projects. Accomplishments of individual institutions are described in subsequent sections of the report.

1. Faculty and Student Involvement: A total of 64 faculty members were significantly involved in teaching, research, and technical assistance in tropical soils. Seven Consortium faculty were stationed in developing countries during the report period. A

total of 88 graduate students majoring in tropical soil science were in residence at the five institutions in 1973-1974. Approximately half (43) of these students conducted their research under actual tropical conditions, either while in residence in Hawaii or Puerto Rico or through overseas assignments supported by the other institutions. The Consortium provides a mechanism for formal and informal coordination of the activities of these soil scientists. This "critical mass" of tropical soil scientists, can significantly contribute to this field, through teaching, research, and utilization programs.

2. Teaching: On-campus teaching has been strengthened substantially through 1) initiation of new courses; 2) the modification of existing courses; 3) participation of teaching faculty in Consortium-sponsored workshops, institutes, and seminars; and 4) contributions of visiting professors and scientists.

Since the grants were made, 21 new courses have been added to the curricula and 18 existing courses have been modified to incorporate subject matter on soils of the tropics. The aggregate result is greater exposure of virtually all under-graduate and graduate students to the characterization and management of soils of the tropics. These changes affect not only students specializing in soil science but also hundreds of students from other agricultural disciplines and some students of social, physical, and biological sciences.

Teaching in the basic soils courses and in soil mineralogy courses were significantly improved by the two Consortium-sponsored

Teaching and Soil Mineralogy Workshops held in Hawaii in 1971 and 1973. Faculty responsible for such courses became familiar with each other's teaching techniques and subject matter areas. In this fashion the significant advances in the mineralogy of oxide systems by the University of Hawaii were transmitted to the other institutions.

The participation of 15 faculty members of the Consortium in the Tropical Soils Institute held at the University of Puerto Rico in 1972 provided the opportunity of exchanging relevant teaching materials in all areas of soil science. The participation of 29 Consortium faculty members in the Seminars held in Nigeria (1972) and Colombia (1974) provided up-to-date teaching materials at the formal sessions and broadened experience in travel to several countries in Africa and South America.

Over the life of the grant, ten visiting professors with long experience in the tropics have been in residence for a full academic term to a year at the different institutions. They have contributed to the teaching program by giving formal courses, seminars, and/or discussions. During the reporting period, Dr. Goro Uehara from the University of Hawaii spent his sabbatical leave at Cornell and North Carolina State Universities where he taught special topic courses. Mr. Claude Charreau of IRAT, France, also spent an academic term at Cornell. Both visiting professors spent shorter periods at other Consortium institutions. In addition, 31 visiting scientists have contributed to the overall effort by giving lectures and informal seminars at the different

institutions. In addition to their contributions to the teaching in tropical soils, visiting professors and scientists have assisted in research programs and have provided firm linkages between the Consortium and their home institutions.

Graduate education has also been strengthened at Cornell and North Carolina State Universities with support from the grant for thesis research of a number of graduate students at key locations in developing tropical countries. This has provided students with opportunities to work on priority soils problems of the developing countries under the constraints associated with the tropical environment and developing country institutions. During the reporting period, 27 graduate students of various nationalities were involved in such programs. This type of experience provides a more meaningful graduate training for future soil scientists for the tropics.

3. Research: The Consortium institutions have used grant funds for research mainly to augment activities supported by other funds. A total of 79 research projects were supported in such a manner at the five institutions during 1973-1974.

Prairie View A&M University used 211(d) funds to provide personnel and materials for applied research focused on problems of the rural poor of less developed countries. The program complements domestic activities funded from other sources which is aimed at the problems of the rural poor in Texas.

Among these activities, graduate research programs have been conducted on models for adopting western farm technology to LDC's,

vegetable production under multiple cropping systems, innovative small farm operations for LDC's, and reforestation of abandoned farmland for Nigeria.

The University of Hawaii is conducting 27 research projects with full or partial grant support. The details are listed in the institution's report. A significant proportion of the projects use the X-ray quantometer purchased with grant funds, which is used for total analysis of rock, soil and plant samples. Research supported with grant funds encompasses all aspects of the field of soil science in Hawaii.

The Universities of Hawaii and Puerto Rico continued with their joint project, supported largely from the grants, for classification and mineralogical characterization of soils of Puerto Rico and Hawaii and for correlation with other soil classification systems used in the tropics. The University of Puerto Rico is also conducting nine research projects on fertilization, management, and conservation of tropical root crops.

The Universities of Hawaii and Puerto Rico are initiating two AID research contracts to conduct "benchmark" soil studies throughout the tropics. This new activity is intended to extrapolate the research results obtained at both universities to the developing countries of tropical regions. Most of the tropical soils research conducted by Cornell and North Carolina State Universities is funded by AID contracts. Cornell University is conducting soil fertility-related research in Puerto Rico and Brazil under Contract AID/csd 2490. Arrangements are in the process to

expand this program to Ghana. Thirteen research projects have been conducted by Cornell staff with major grant support during the report period. Grant funds have been used to study questions raised by contract research but not strictly within contract objectives. North Carolina State University is conducting research in Brazil, Peru, and Central America on agronomic-economic aspects of soil management of tropical savannas, jungles, and volcanic highlands under contract AID/csd 2806. It also conducts a technical assistance program on international soil fertility evaluation throughout Latin America under contract AID/1a 646. The nine research projects funded by the grant at this institution relates to questions not answered directly by the activities under the contracts, and obtaining additional data for extrapolation purposes.

Many research activities are conducted jointly by more than one university. The Cornell contract activities in Puerto Rico have been conducted as a joint project with the University of Puerto Rico. Research activities in Brazil are jointly operated by North Carolina State and Cornell Universities. The University of Hawaii and Prairie View A&M conduct jointly research on soil solution phosphorus and crop growth. The Universities of Puerto Rico and Hawaii conduct joint soil genesis studies and expect to conduct research under their new contracts jointly. The development of a classification system for soil fertility-management problems at North Carolina State University is closely correlated with the objectives of the Hawaii-Puerto Rico contracts.

Prairie View A&M and the University of Puerto Rico jointly sponsored a workshop on tropical savannas in the Dominican Republic on January, 1973.

During the reporting period, the Consortium as a whole produced 110 scientific papers on tropical soils, consisting of 39 journal articles or bulletins, 13 theses and 58 processed papers.

4. Consultation: Individuals of the Consortium institutions made 107 visits to 33 countries during 1973-1974 on matters pertaining to tropical soils as follows:

Australia	El Salvador	Kenya
Barbados	Ethiopia	Mexico
Belgium	France	Netherlands
Bolivia	Ghana	Nigeria
Brazil	Guatemala	Panama
Cameroons	Honduras	Paraguay
Canada	Indonesia	Peru
Colombia	Ivory Coast	Senegal
Costa Rica	Iran	Trinidad
Dominican Republic	Israel	Venezuela
Ecuador	Italy (FAO)	Vietnam

These visits ranged from consultations about cooperative research and participation at conferences, to action programs. Some were the result of AID's requests for consultation. Not all visits were supported by 211(d) funds, but all contributed to the effects of the program. A total of approximately 938 man-days were spent in such visits.

Within the United States, individuals consulted with soil scientists of other U. S. Universities and Government agencies including several AID-sponsored workshops and conferences. All of the Consortium institutions were represented at the fall meeting

5. Library Reference: All of the institutions have continued to increase library resources and improve reference facilities. Cornell University studied the possibility of preparing a comprehensive bibliography on tropical soils on a continuing basis. After a thorough study, it was concluded that such a task was beyond the capabilities of the Consortium. Cornell staff undertook the responsibility of compiling and publishing a bibliography of the 12,000 references on soils of the tropics held at the Soil Geography Unit of the Soil Conservation Service. It is expected that the job will be completed during the following year. The same institution published as "Agronomy Mimeos" partially annotated bibliographies on manganese and zinc in the tropics. North Carolina State University reprinted its "Review on Soils Research in Tropical America" in English and Spanish in their Technical Bulletin series. The University of Hawaii entered into an agreement with the Agricultural Research Service of USDA to establish an on-line bibliography and current research awareness service for tropical agricultural research. Prairie View A&M University continued to catalogue their holdings related to savanna soils and the rural poor in a computerized storage-retrieval system, for use by soil scientists worldwide.

#### D. IMPACT OF GRANT-SUPPORTED ACTIVITIES IN DEVELOPING INSTITUTIONAL CAPABILITIES

The impact of the 211(d) grants varies in detail among the five institutions. The kinds of impact are described in the reports of the individual

institutions, which follow this section. A common denominator for all, however, is the effect the grants have had on the capabilities of professional staff.

For the Consortium as a whole, more scientists are engaged in studies of tropical soils, and the collective institutional capabilities have been enhanced accordingly. Even at the Universities of Hawaii and Puerto Rico, where the focus of attention is normally on the tropics, professional staff have been added to increase capabilities in the least developed subject-matter areas. For the three institutions in the temperate zone, the activities generated by the grants have involved a high proportion of the existing professional staff, many of whom had previously had little commitment to studies of tropical soils. The Consortium collectively, now has 64 members of the respective faculties who are actively studying the applications of soil science in the tropics. This is about 29 more than at the time the grants were initiated.

Quite apart from numbers of people, however, the grants have provided opportunities for experience not only in the tropics but also in varied environments of the tropics. The soils and environments of the tropics are at least as varied as those of temperate regions. In four years time, the perspective of the faculties of all institutions has been increased immensely by personal experiences with soils and soil problems that had been perceived vaguely if at all. The South American experience of 18 faculty members during the Cali Seminar and post-seminar tour, for example, revealed many kinds of soil and soil problems that had not been comprehended before.

The aggregate impact is more than the sum of individual experiences. The interaction among individuals from different institutions within the Consortium has been both stimulating and educational. The interaction with scientists of other institutions has added new dimensions of thought. The net effect of all of these factors on total capabilities and enthusiasm cannot be measured in quantitative terms, but it is very large.

#### E. UTILIZATION IN DEVELOPING COUNTRIES

The previous sections describe the accomplishments in the areas of teaching, research, consultation, and library resources consistent with the stated objectives of the grants: to increase the institutions' expertise in tropical soils. With the increase in institutional capabilities come responsibilities for putting the expertise into practice in tropical developing countries. A significant proportion of the Consortium efforts were directed towards utilization during the reporting period. Thus, the "outputs" of the overall program can be discussed in the following categories: Training of LDC soil scientists, on-site research in LDC's, transfer of new information to LDC, establishment of linkages with LDC institutions, and the formation of an international network in tropical soils.

1. Training of LDC Soil Scientists: During the reporting period, 53 graduate students from developing countries were undergoing graduate training in tropical soils at the five institutions. The establishment of a Master of Science program in soils at Prairie View A&M was accomplished with grant support. The depth and quality of their training is probably the most comprehensive to date due to the improved quality of the teaching program and the emphasis on conducting thesis research in tropical environments.

In addition, LDC soil scientists participated in the six-week training course on soil fertility evaluation held at North Carolina State University for the eight consecutive year. The impact of these trained people on the total development effort remains to be determined but on the basis of past experience, they will become leaders in teaching, research, and advisory services in their countries. Many will advance to administrative posts where they will help determine policy.

2. On-Site Research: Research on tropical soil problems conducted in the developing countries by the Consortium institutions, although mainly supported by other AID funds, have had a measurable impact not only in the countries where they have been conducted but in areas with similar ecological conditions as well. The effects of the North Carolina State University AID/1a 646 soil fertility evaluation program have resulted in the development of advanced soil testing laboratories in most Latin American countries. These efforts have been extended to parts of Southeast Asia also. The joint Cornell-North Carolina State University research program on the management of extremely acid soils of the Campo Cerrado of Brazil has already produced significant new practices applicable to other areas with similar ecological properties. The first systematic attack of soil management under shifting cultivation in the Amazon Jungle has been initiated by North Carolina State University in Peru. The evaluation of silting problems of the Mekong delta by the University of Hawaii has provided a sound basis for policy planning of the regional scale. Grant funds have been used

to estimate the extrapolation of these findings to other areas. A new cooperative research project between Prairie View A&M University and Njala University College of Sierra Leone was established to study multiple cropping systems. An expected expansion of the Consortium's on-site research activities in LDC's during the next two years will augment these direct contributions.

3. Transfer of New Information to Developing Countries: This process consists of organizing international seminars, participating in national conferences held in various developing countries, and issuing and distributing publications.

During the reporting period, the Consortium organized a second major international seminar which was held at CIAT, Cali, Colombia on February 10-14, 1974. North Carolina State University was assigned this responsibility by the Executive Committee. The Seminar on "Soil Management and the Development Process in Tropical America", was attended by 209 soil scientists from 21 developing countries and 5 developed countries. A total of 32 papers describing new and relevant information on the subject were presented and distributed in mimeographed form in English and Spanish. The entire group participated in discussions related to establishing research priorities and the possibility of organizing a research network in tropical soils. A tour to key areas in Colombia, Peru, and Brazil followed the seminar. The details are described in North Carolina State University's report. The proceedings will be published in both languages during 1975.

Consortium members actively participated in the following

conferences held in developing countries during the report period: FAO/CIDA Regional Seminar on Shifting Cultivation (Nigeria), Colombian Society of Soil Science, IICA Multiple Cropping Conference (Costa Rica), IICA Land Use System for the American Humid Tropics (Peru), Symposium on Sulfur in Australasian Agriculture (Australia), Peruvian Society of Soil Science, and the Latin American Society of Soil Science (Venezuela). The interchange of information and interaction with LDC colleagues at such meetings are of considerable value.

The Consortium output of scientific publication provides another means of technology transfer. During the reporting period, the proceedings of the Symposium on Tropical Savanna Soils was published by Prairie View A&M University in Spanish, and the Review of Soils Research in Tropical Latin America was published by North Carolina State University in Spanish and English. The latter institution distributes its tropical soils publications automatically to a mailing list of 450 individuals and institutions throughout the world. Other universities also have distribution systems. All Consortium publications are entered into the AID Research Abstracts and thus made available to USAID missions and other institutions in photocopy form at cost.

A Directory of Tropical Soil Scientists is in the process of preparation by the Consortium. This directory will serve to identify qualified soil scientists for specific consulting tasks or long-term overseas assignments. Included are tropical soil scientists from developed and developing countries. Prairie View A&M University is responsible for the inventory and retrieval through a

computerized program.

4. Towards an International Network in Tropical Soils: Substantial efforts have been made by the five institutions to establish linkages with other institutions concerned with tropical soils problems throughout the world. Contacts made through visiting professors, at conferences, and during on-site visits are developing into meaningful linkages. The term "linkage" refers to cooperative activities of an active nature in training, research, or technical assistance. The term "contact" refers to activities aimed at becoming aware of what other institutions are doing and exchange of publications. By the end of the reporting period, the five universities have established meaningful linkages with the following numbers of institutions in developing countries:

Brazil:	7	Nigeria:	2
Bolivia:	1	Panama:	2
Colombia:	4	Peru:	6
Costa Rica:	3	Philippines:	2
Dominican Republic:	2	Senegal:	1
Ecuador:	2	Sierra Leone:	1
El Salvador:	2	Surinam:	1
Ghana:	2	Tanzania:	1
Guatemala:	1	Trinidad:	1
Indonesia:	1	Venezuela:	2
Mexico:	2	Vietnam:	1
Nicaragua:	1		

Similar linkages have also been established with developed country institutions in Australia, Belgium, France, Italy, the United Kingdom, and within the United States. The five institutions also maintain contacts with over 50 additional institutions in developing countries. The growing awareness of the need to strengthen the existing informal network in tropical soils let the Consortium institutions to study the different possibilities of formalizing

such a network and accelerate the transfer of information process. Several proposals are presently under study. Connected with it are several alternatives of modifying the Consortium structure for it to contribute more to this effort.

#### F. OTHER RESOURCES USED FOR GRANT-RELATED ACTIVITIES

The five institutions have contributed salaries and related costs from sources other than the 211(d) grants on a large number of their faculties who spend a significant amount of time on teaching, research, and consultation on soils of the tropics. At the Universities of Hawaii and Puerto Rico where most work in soil science is focused on the tropics, and to some degree in the other institutions as well, much of the institutional contribution for personnel service was not necessarily generated by the 211(d) grants. Nevertheless, it contributes to grant objectives. At some of the institutions, a major part was generated by grant activities. The aggregate expenditures on personnel for tropical soil studies from sources other than 211(d) funds, though not appraised quantitatively, greatly exceeds expenditures for salaries and related costs under the grants, especially if salaries of supporting staff and fringe benefits not supported by 211(d) funds are included.

#### G. PLAN OF WORK FOR 1974-1975.

The Consortium will continue cooperation on joint instructional, research, and technical assistance projects during 1974-1975. All the cooperating institutions will collaborate in a special Tropical Agronomy Field course to be held at the University of Hawaii during the summer of 1975 at the request of the International Agronomy Division of the American Society of Agronomy. Preparation for the third major international

seminar to be held at Hyderabad, India in early 1976, will take place during the year. The University of Hawaii is responsible for coordination of this project. Preparations are also underway for three additional tropical soils institutes to be held in Africa, Asia, and Latin America during the next two years. A special committee of Consortium staff has been formed to plan such events. The Consortium has been requested to assist AID in the formulation of long-term research policy on soil and water, on research networks, varietal tolerances to soil problems, and on the drought-stricken Sahel region. The five institutions are expanding their research contract activities and expect to continue to consult in developing countries to the extent feasible as opportunity and need become evident. A clear strategy for the establishment of an international network for tropical soils is expected to be developed during the next year.

Pedro A. Sanchez, Secretary  
Executive Committee

REPORT OF  
CORNELL UNIVERSITY



REPORT OF CORNELL UNIVERSITY  
FOR THE PERIOD  
JULY 1, 1973 TO JUNE 30, 1974

- A. TITLE: A Grant to Strengthen the Capabilities of Cornell University for Special Problems of Tropical Soils (Grant AID/csd 2834)
- B. GRANTEE: Cornell University
- C. DIRECTOR: Dr. Matthew Drosdoff
- D. STATISTICAL SUMMARY
1. Period of Grant: June 30, 1970 to June 30, 1975
  2. Amount of Grant: \$500,000
  3. Expenditures: To be submitted as a separate document
- E. NARRATIVE SUMMARY

During the four years of the grant, faculty involved in the program for the tropics has increased from six to sixteen. Two new courses on the subject have been added, and eleven others, including two inter-departmental offerings, have been substantially revised to incorporate subject matter relevant to the tropics. These courses reach about 700 students annually. Seventy-one graduate students having career commitments to LDC's have been candidates for advanced degrees, including 51 from 24 developing nations. Thirty-nine total and 26 LDC students were engaged in the program during 1973-74. Faculty expertise has been strengthened by six Visiting Professors who are authorities on the tropics, two in 1973-74, and by direct experience in LDC's. Five Visiting Scientists for short periods have contributed.

Research has concentrated mainly on problems raised by work of contract AID/csd 2490 but peripheral to the objectives of that contract. A smaller

number of other relevant subjects have been investigated. Nineteen of such short-term projects have been supported largely by 211(d) funds. Ten others have been similar in character but supported mainly from other sources. Ten were supported by 211(d) funds and three from other sources during 1973-74.

These activities have produced twelve published articles, nine manuscripts accepted for publication, seventeen processed articles and master's theses catalogued in libraries, and sixteen typescript reports for internal use. Thirteen of the processed articles have been reproduced in quantity for distribution to AID and selected institutions and individuals.

During the four years, Cornell personnel have spent 589 man-days in consultation in LDC's, 87 man-days in conferences in LDC's, and 86 man-days in domestic consultation on the topic of tropical agriculture. During 1973-74, 208 man-days were spent in consultation, of which 143 were in LDC's. These are exclusive of consultation with members of the Consortium on Consortium activities and exclusive of activities directly concerned with contract AID/csd 2490. About 40 man-days of those listed as domestic were for AID on problems of LDC's.

Linkages involving cooperation on activities related to the subject of the grant have been established with 13 institutions of LDC's in nine countries and with six institutions of developed nations devoted to agricultural development in LDC's. Seven of the former and two of the latter involved active cooperation during 1973-74. In addition, the University has established firm contacts but without collaboration on activities with 19 other institutions of 12 LDC's, exclusive of contacts with 14 others through graduate students.

Holdings of items pertaining to the tropics have been increased by about 400 volumes in the Agronomy reference library as an adjunct to the extensive holdings of the University library. A consultant is assembling the 12,000 references held by the Soil Conservation Service for publication as a bibliography of soils of the tropics.

#### F. DETAILED REPORT

1. General Background and Purpose of the Grant: The general background and purpose of the five grants to Consortium members are described in the section on the "Consortium Program" as a whole. Within that context, Cornell University has focused its project on the development of competence of a cadre of faculty to understand the applications of the varied elements of soil science in the tropics and to apply that understanding to practical cultural systems for food-crop production on soils of the tropics.

Cornell's interest in the grant as an instrument for domestic institution building was based on two long-term commitments. First, the University is committed to a quality domestic program of teaching, research, and public service. It has long recognized that this cannot be achieved unless its faculty has world-wide perspective of their subject matter. This is especially critical in soil science, which cannot be a complete science without understanding of the kinds of soil and their behavior in the tropics. Second, the University has long recognized obligations as a public institution to serve as a resource of knowledge for national and international programs and for policy development at the State and National levels. This too requires world-wide perspective of subject matter. Consequently, many of the University faculty, including those in soil science, have been encouraged to work in varied physical and cultural

environments as a matter of policy.

Under University policies, faculty members representing most of the major specialties of soil science had acquired substantial experience with soils of the tropics before the grant was made. The grant offered an opportunity to augment existing competencies and to consolidate subject matter specialties into a unified perspective of soils of the tropics in relation to their use and culture.

In accepting the grant, the University anticipated serving the objectives of AID as a development agency while reinforcing its own commitments to both quality education and public service. Within limits imposed by educational commitments, it anticipated increased and more effective direct participation of faculty in development programs and policy decisions of immediate concern to AID. It also anticipated major, and probably greater, long-term impact on international development through its many foreign students and through American students having international commitments.

2. Objectives of the Grant: The immediate objective of the grant is to develop a comprehensive and unified perspective of soils of the tropics in relation to their potentials and requirements for use. This is not an end in itself. The long-range purpose of the grant is to serve national goals in international agricultural development.

The long-range purpose of the grant implies development of a quality educational program on soils of the tropics for both foreign and domestic students at Cornell. This will contribute to manpower needs of the future both for developing nations and for domestic activities in the international field. The purpose also implies development of a resource base of knowledge about soils of the tropics at Cornell which can actively contribute to international agricultural development. It also implies development of

linkages with soil scientists of the tropics and their institutions to facilitate such contributions.

The immediate objective implies a focus on the combination of practices necessary for viable cultural systems for tropical soils. Achievement of the objective requires coordinating knowledge of at least four areas of soil science--(1) soil characteristics and classification, (2) plant nutrient-soil relationships, (3) soil-water-plant relations, and (4) conservation and protection of different kinds of tropical soils. In addition, it requires supporting inputs to help understand (1) the impact of climatic conditions on soil and crop behavior, (2) water management, (3) crop management, and (4) the economic and social environments within which knowledge and technology must be applied. To fulfill the objective, the grant provides for:

- (1) Participation of Cornell faculty, one of whom would serve as Cornell project leader and would coordinate Cornell's efforts with those of the other four cooperating institutions.
- (2) Visiting professorships through which Cornell would bring additional expertise and experience to the project.
- (3) Graduate assistantships and related support for students contributing to this project, including exchange students from the four cooperating institutions.
- (4) Travel of contributing staff and students.
- (5) Modification of existing courses and development of new courses to enhance teaching about soils of the tropics
- (6) Strengthening library and other informational services and preparation of training materials.

The activities under the grant have been consistent with these purposes.

As the project enters its fifth year, changes are contemplated to bring the expertise developed to bear more directly on programs in developing nations.

3. Accomplishments: Accomplishments of the project are discussed under six major topics: 3.1. Teaching, 3.2. Research, 3.3. Publications, 3.4. Consultation, 3.5. Linkages and Contacts, and 3.6. Library and Reference. Under each of these topics, accomplishments for the first four years of the grant ending June 30, 1974 are summarized and are followed by an account of activities for the 1973-74 reporting year.

3.1. Teaching: During the four years of operation institution building has focused on enhancement of the expertise and perspective of the faculty in applications of soil science for the tropics. Six authorities on soils and cultural systems of the tropics have been brought to the campus for periods of three to six months for this purpose and to teach. Five others were brought to Cornell for shorter periods on special subjects. The faculty has also been given opportunities to work in the tropical environment and with soil samples from the tropics. Sixteen faculty members have been involved in a variety of such activities and now constitute a major resource of knowledge and expertise for soils of the tropics and their use and management.

The expertise and perspective of this cadre of faculty is reflected in their teaching. Two new courses that focus on the tropics have been added. Eleven other courses have been modified substantially to incorporate and enlarge on subject matter relevant to the tropics. A seminar on soils of the tropics has been established as a regular activity. These courses enroll about 700 students annually from a broad spectrum of subject matter areas of the University. The impact this teaching has had and will continue to have on thousands of students over the years cannot be measured quantitatively, nor can their influence on LDC's directly, and on U.S. policy as regards foreign assistance be estimated. It can be

said that thousands of students from such diverse fields as sociology, economics, government, and engineering as well as agriculture and biological sciences will work in society with far better understanding of the soil resources and their use in the tropics than would otherwise have been possible. The courses affected are the following:

- Agronomy 200 - The elementary course in soil science
- Agronomy 301 - The first course in soil classification and survey
- Agronomy 324 - The first course in soil fertility
- \*Agronomy 401 - Geography and appraisal of soils of the tropics
- Agronomy 405 - Soil clay mineralogy
- Agronomy 406 - Soil survey interpretation
- \*Agronomy 422 - Tropical agriculture
- \*Agronomy 480 - Management systems for tropical soils
- Agronomy 503 - A graduate course in soil genesis and classification
- Agronomy 701 - A graduate course in soil chemistry
- Agronomy 724 - A graduate course in soil fertility
- \*Animal Science 403 - Forage production in the tropics
- \*International Agriculture 602 - Special studies of agricultural problems in the tropics

Those marked by an asterisk are specific to the tropics. The last two listed are taught jointly with faculty of other departments.

Over the four years of the grant, 71 graduate students having career commitments to agriculture in developing nations have majored in the Department. Thirty-nine of the 71 were in residence in 1973-74. Fifty-one came from 24 different developing nations, distributed as follows:

The Caribbean Area	- 7 from 4 countries
South America	- 10 from 5 countries
East and Southeast Asia	- 15 from 5 countries
South Asia	- 8 from 3 countries
East Africa	- 3 from 3 countries
West Africa	- 8 from 4 countries
	<u>51 from 24 countries</u>

The other 20 students are citizens of the United States (17), the Netherlands (2), and Canada (1) with career commitments to agricultural development in LDC's. Forty of the 71 are Ph.D. candidates. Twenty students will have completed thesis research in LDC's when they graduate. The impact

of these trained people on LDC's remains to be determined, but on the basis of past experience, they will become leaders in teaching, research, and advisory services in developing nations. Many will advance to administrative posts where they will help to determine policy.

In addition to the graduate majors in the Department, the faculty has served an approximately equal number of students majoring in other disciplines and minoring in the Department. The faculty has also served as guest lecturers in courses of other disciplines of the University and at other Universities of the United States and Canada. They have participated in an institute and two major seminars overseas for soil scientists of the tropics. They have participated in four workshops for members of the Consortium.

During 1973-74, teaching activities specific to soils of the tropics included the following, which were supported in part or entirely by 211(d) funds.

1. Visiting Professor Goro Uehara of the University of Hawaii delivered a series of ten special lectures on recent developments in soil chemistry, mineralogy, and physics and their significance to use and management of soils of the tropics.
2. Visiting Professor Claude Charreau delivered a series of thirteen special lectures on soils and environment of the Sahelian zone of West Africa in relation to soil use and cultural systems in dry tropical areas. The lectures will be published and distributed.
3. A special three-credit course was given during the summer session of 1973 on Natural Resource Potential for Food Production in the Tropics designed especially for students having limited agricultural background.
4. Faculty and staff gave 16 special lectures and seminars on subjects relating to soils of the tropics at Cornell (6) and in Canada (2), the Netherlands (1), Colombia (2), Brazil (2), Hawaii (2), and the State University of New York at Buffalo (1).

5. Faculty participated in development of an interdisciplinary course on problems of agriculture in the tropics and in two weeks of field study in the Dominican Republic and Puerto Rico as part of the course.
6. Thirty-nine graduate students having career commitments to agricultural development in LDC's were enrolled. Twenty seven of these were from LDC's. Ten students were engaged in thesis research in LDC's part or all of the year, as follows:

Character and formation of laterite	- Venezuela
Soil production potential and cropping systems	- Nigeria
Cultural systems including rice and cassava	- Brazil
Water resources for potential irrigation	- Brazil
Soil water-crop relations	- Brazil
Crop physiology-soil relations	- Brazil
Quinoa culture and production	- Bolivia
Soil changes in the draw-down area of the Volta reservoir	- Ghana
Rhizobium for the tropics	- Colombia
Nutrition of cassava	- Colombia

7. A collection of 67 crops of the tropics has been assembled and is grown continuously under greenhouse conditions as a teaching facility open to all relevant courses and to interested individuals.
8. A collection of approximately 800 colored 2 x 2 slides of tropical crops, cultural systems and management practices has been assembled as a teaching resource.

3.2. Research: During the four years ending June 30, 1974, nineteen problems have been investigated under funds largely from the 211(d) grant. Sixteen of these dealt with questions raised by research under contract AID/csd 2490 but which were not strictly within the scope of its objectives. These were undertaken to elaborate or explain results of that research. An additional twelve problems were investigated under funding independent of both contract AID/csd 2490 and grant AID/csd 2934 (211d) except for portions of salaries from 211(d) funds for some faculty who directed graduate student research. All thirty-one of these research activities are listed here with the names of investigators and the fiscal years of the investigations. Results of those in progress

during the 1973-74 reporting period are reported later in this section.

A. Major support from 211(d) funds

1. \*K. D. Ritchey, student, and R. Fox, advisor. Micronutrients limiting yields of Oxisols and Ultisols of Puerto Rico. 1971-1972-1973.
2. \*K. D. Ritchey, student, and R. Fox, advisor. Wick-watering techniques for pot culture in tropical environments. 1972-1973.
3. \*F. F. Ferreira, student, and T. Scott, advisor. Fate of nitrogen from fertilizers applied to tropical soils. 1971-1972.
4. O. Odeyemi, student, and M. Alexander, advisor. Factors affecting the rate and character of organic matter decomposition with reference to tropical conditions. 1972-1973.
5. M. Rodriguez, student, and D. Bouldin, advisor. Calcium and magnesium release from highly weathered soils. 1972-1973-1974.
6. J. Bockus, student, and M. Drosdoff, advisor. Climatic data and incidence of drouth as it affects response to fertilizers in the tropics. 1972.
7. C. Kao, student, and D. Bouldin, advisor. Transformations of nitrogen in flooded soils. 1972.
8. C. Kao, student, and D. Bouldin, advisor. Effects of soil acidity on root development. 1973.
9. G. Amedee, student, and M. Peech, advisor. Liming and loss of calcium in highly weathered soils of the humid tropics. 1973-1974.
10. S. Mughogho, student, and M. Weaver, advisor. The role of organic forms of soil phosphorus in phosphorus nutrition in soils of the tropics. 1973-1974.
11. \*M. Weaver, professor. Mineralogy of selected soils of the humid tropics. 1972-1973-1974.
12. \*M. Cline, professor. Application of research results to soils of the Central Plateau of Brazil. 1973.
13. \*T. Forbes, student, and R. Arnold, advisor. The potential for food crop production on a soil climosequence of West Africa. 1974.
14. \*L. Daugherty, student, and R. Arnold, advisor. Characteristics of soils with plinthite in Venezuela. 1974.
15. \*T. Scott, professor. Evaluating soil testing methods for available phosphorus for soils of the humid tropics. 1974.

16. \*D. Lathwell, professor. A soil test for nitrogen-supplying power for soils of the humid tropics. 1973-74.
17. \*J. Prunzel, student, and P. Zwerman, advisor. Potential for water empoundment for supplemental irrigation on the Central Plateau of Brazil. 1974.
18. \*M. Whittaker, student, and H. MacDonald, advisor. Production of Quinoa in Bolivia. 1974.
19. \*J. Silva, Visiting Professor. Potential for response of crops to silicates on soils of Puerto Rico. 1973.

B. Limited supported from 211(d) funds

20. \*H. Zandstra, student, and D. Bouldin, advisor. Aluminum toxicity in some highly weathered soils. 1972-73.
21. \*G. Naderman, student, and M. Drosdoff, advisor. Yellowing of rice as related to root development and mineral nutrition in soils of the Eastern Plains of Colombia. 1972-73.
22. M. Carrasco, student, and M. Peech, advisor. Distribution of electrical charges in Chilean soils derived from volcanic ash. 1972-73.
23. B. Van Raij, student, and M. Peech, advisor. Electrochemical properties of some Brazilian soils. 1971-1972.
24. \*W. S. Reid and J. Silva (Hawaii), professors. Lime requirement of some soils of the tropics. 1973.
25. \*S. Danso, student, and M. Alexander, advisor. Rhizobium and legume inoculation for soils of the tropics. 1973-1974.
26. \*A. Ngongi, student, and H. MacDonald, advisor. Nutrition of cassava. 1974.
27. D. Dumith, student, and R. Arnold, advisor. Properties of soils high in clay in Venezuela. 1973.
28. R. Abreu, student, and G. Olson, advisor. Considerations for a cooperative soil survey in Venezuela. 1973.
29. \*D. Kass, student, and M. Drosdoff, advisor. Cultural systems of mixed cropping of cassava, upland rice, and maize in Brazil. 1973-74.
30. \*J. Amatekpor, student, and M. Drosdoff, advisor. The effect of seasonal flooding on the modification of soil properties in the Volta Lake Drawdown Area in Ghana. 1973-74.
31. \*W. Philipson, student, and M. Drosdoff, advisor. Analysis and characterization of Philippine crop occurrence in relation to soil and climatic factors. 1971-1972-1973.

\*Those marked with an asterisk have involved work overseas by the investigator.

The progress of research supported by 211(d) funds during 1973-74

follows:

1. Calcium and magnesium release from highly weathered soils. M. Rodriguez, graduate student.

Total Ca, Mg, and K in soils of the Llanos of Colombia are approximately <100, 800, and 2000 ppm, respectively. Of these small amounts, only about 4 to 20 ppm of Ca, 8 ppm of Mg, and 20 ppm of K are exchangeable, and essentially none of the reserve is converted to exchangeable form on incubation with wetting and drying. The reserves are apparently in non-weatherable minerals. All three of these elements must be limiting as plant nutrients.

2. Liming and loss of calcium in highly weathered soils of the humid tropics. G. Amedee, graduate student.

KCl-extractable acidity greatly underestimated and exchange acidity by BaCl<sub>2</sub>-triethanol amine overestimated the lime requirement of 9 Oxisols and Ultisols of Brazil, Colombia, and Puerto Rico. The capacity of these soils to adsorb cations was markedly increased by liming. The pH-dependent charge of these soils was as effective as the permanent charge of soils of temperate regions in adsorbing and preventing loss of Ca<sup>++</sup> and other cations.

3. The role of organic phosphorus in phosphorus nutrition in soils of the tropics. S. Mughogho, graduate student, and M. Weaver.

Oxisols and Ultisols of Puerto Rico can supply up to 50 ppm of phosphorus by mineralization. Amounts were less for selected soils of Malawi. The amount of phosphorus released by mineralization of organic matter is important in phosphorus nutrition and appears to depend in part on cropping history of the soil.

4. Mineralogy of selected soils of the humid tropics. M. Weaver.

Mineralogical characterization started in previous years was extended to Oxisols of Brazil and to Ultisols of Ghana during 1973-1974. Mineralogically, the clay fractions of soils of the Central Plateau of Brazil are 75 to 95 percent kaolinite, gibbsite, iron oxides and amorphous material but with major unexplained differences in the proportions of kaolinite and gibbsite, one or the other of which is most abundant. In the coarser textured soils, silication of active oxidic surfaces is high, contributing to increased cation retention and decreased phosphorus retention per unit of clay and to some degree offsetting the effects of low clay content. This may account for the qualitative observation of Brazilians that the coarse loamy soils behave as well as the clayey soils of the area. For the Ultisols of Kumasi, Ghana, kaolinite was  $2/3$  to  $3/4$  of the clay fraction with minor amounts of goethite and about  $1/5$  amorphous material. No gibbsite was detected. This may signify important management differences from the soils of Brazil.

5. The potential for food-crop production on a soil climosequence of West Africa. T. Forbes, graduate student.

Studies in cooperation with IITA are under way on morphology and chemical and physical properties of soils in a sandy formation extending from rainfall of 900 mm in Togo to 2000 mm in Eastern Nigeria in conjunction with maximum yield trials and a survey of small farmer cultural systems and yields. Results are not available at this time.

6. Characteristics of soils with plinthite in Venezuela. L. Daugherty, graduate student.

Field studies in cooperation with soil scientists of Ministerio de Obras Publicas of Venezuela have been completed for characterization of the

morphology and geomorphic relationships of soils having oxide-rich layers that harden on exposure. Laboratory phases on samples from Venezuela are in progress at Cornell.

7. Evaluating soil testing methods for available phosphorus for soils of the humid tropics. T. Scott.

Chemical soil tests for available phosphorus are being evaluated against phosphorus response in field experiments with Oxisols and Ultisols in Puerto Rico and in greenhouse work with eight soils and three crops. Results are not available at this date.

8. A soil test for nitrogen supplying power for soils of the humid tropics. D. Lathwell.

Nitrogen uptake by crops is highly correlated with organic nitrogen extracted by neutral salt solutions for Oxisols and Ultisols of Puerto Rico and central Brazil. The predictive value of the test was poor for soils of IITA in Nigeria, where crop residues were returned. The effects of residues are being investigated in cooperation with IITA.

9. The potential for water empoundment for supplemental irrigation on the Central Plateau of Brazil. J. Pruntel, graduate student.

This investigation is an outgrowth of soil studies by Cline and Buol reported in 1973. They suggested that short dry periods during the rainy season are critical and that the potential for small empoundments for supplemental water should be investigated. Field studies began in June, 1974.

10. Production of Quinoa in Bolivia. M. Whittaker, graduate student.

This staple food crop of highlands of Bolivia and adjacent areas has high protein. Little is known about its culture and potential. Local cultural practices were studied during the summer of 1973, and other information about the crop and its culture is being assembled.

Four other studies having no AID support were in progress during 1973-1974.

1. Rhizobium and legume inoculation for soils of the humid tropics. S. Danso, graduate student.

Work at CIAT in Colombia has demonstrated that Rhizobium can persist in competition with soil microflora under tropical conditions, but is subordinated or eliminated by some pathogenic organisms.

2. Nutrition of cassava. A. Ngongi, graduate student.

Work in Colombia in cooperation with CIAT was started in February, 1974 and is proceeding. Results are not yet available.

3. Cultural systems of mixed cropping of cassava, upland rice, and maize in Brazil. D. Kass, graduate student.

The first crops are approaching harvest in systems that simulate mixed cropping by farmers on an experimental station and in the plantings of small farms near Belem. Results will be reported for 1974-1975.

4. The effect of seasonal flooding on the modification of soil properties in the Volta Lake Drawdown area in Ghana. J. Amatekpor, graduate student.

Changes in the physical and chemical properties of these soils after five years of intermittent flooding are being studied with the objective of determining what effects these changes might have on crop production in future years.

3.3. Publications and Manuscripts: During the four years of the grant, Cornell scientists have issued the following on soils and related subjects for the tropics:

- a. 12 published articles, including Ph.D. theses
- b. 9 manuscripts accepted for publication
- c. 17 processed articles and Master's theses catalogued in libraries
- d. 16 typescript reports for internal use, mainly

Thirteen of the processed articles have been reproduced in quantity for distribution to AID and selected institutions and individuals.

Publications and manuscripts issued during 1973-74 follow. Those directly supported in whole or in part by 211(d) funds are marked by an asterisk.

a. Published Articles

- \*Drosdoff, M. 1974. Recent research on soils of the humid tropics. McGraw Hill Yearbook of Science and Technology, 1974, pp. 377-378.
- \*Gonzales, R. A., Schargel, R., and Arnold, R. 1973. Normas y especificaciones para los estudios de suelos de Division de Edofolia, M.O.P., de Venezuela. Div. Edofol. M.O.P. Caracas. 35 pp.
- Olson, G. W. 1973. Improving uses of soils in Latin America. Geoderma 9:257-267.
- Olson, G. W. 1973. Geographic aspects of soil use considerations in Latin America. In Latin American Development Issues. Proc. Conf. Latin Amer. Geogr. Vol. 3, pp. 91-100, A. D. Hill, ed., CIAG Publ., Inc., East Lansing, Mich.
- Schmidt, D. R., MacDonald, H. A., and Kelly, W. C. 1973. Yield and content of iron, manganese, and copper in tropical leaf vegetables when variously fertilized. Comm. Soil Sci. and Plant Anal. 4:95-103.
- \*Weaver, R. M. 1974. A simplified determination of reductant-soluble phosphorus in soil fractionation schemes. Soil Sci. Soc. Amer. Proc. 38:153-154.

b. Articles Accepted for Publication

- \*Ritchey, K. D. Use of wick-watering for greenhouse pots in the tropics. Accepted for Tropical Agriculture (Trinidad).
- \*Ritchey, K. D. and Fox, R. H. Limitations to productivity of some Oxisol and Ultisol subsoils. Accepted for Jour. Agr. Univ. Puerto Rico.
- \*Weaver, R. M. Inorganic and organic phosphorus occurrence in some highly weathered soils of Puerto Rico. Accepted for Tropical Agriculture (Trinidad).

c. Manuscripts Prepared for Publication

- Alexander, M. Environmental consequences of rapidly rising food output.
- \*Charreau, C. Soils of the tropical dry and dry-wet climatic areas and their use and management. A comprehensive treatment based on a series of lectures about the Sahelian zone of West Africa. Approximately 400 typed pages.

- \*Drosdoff, M. and Cady, F. B. Design of soil fertility research for the tropics: I. Some Cornell University experiences. II. Rationale for design of subsequent studies. Papers presented at the Workshop on Experimental Design, Honolulu, Hawaii. May, 1974.
- Fox, R. H., Badillo, J., Del Valle, R., and Scott, T. W. Response to phosphorous fertilization by corn in greenhouse, sunken drum and field experiments.
- Gonzalez, E., Wolf, J., Naderman, G., Soares, W., and Galrao, E. Relationship of aluminum toxicity with root growth, water uptake, and yield of corn in an Oxisol (Latosol Vermelho Escuro) of the Federal District. A paper to be presented at the Brazilian Genetics Society meetings in Recife.
- Soares, W., Lobato, E., Gonzalez, E., and Naderman, G. Liming of soils associated with the Brazilian Cerrado. A paper presented at the Seminar on Soil Management and the Development Process in Tropical America at Cali, Colombia.
- Soares, W., Galrão, E., Gonzalez, E., Yost, R., and Naderman, G. Preliminary results in experiments with lime and phosphorus on a Dark Red Latosol near Brasilia. A paper presented at the XIV Annual Meeting of the Brazilian Soil Science Society at Santa Maria Rio Grande du Sul.
- \*Uehara, G., and Keng, J. Management implications of soil mineralogy in Latin America. A paper presented at the Seminar on Soil Management and the Development Process in Tropical America at Cali, Colombia. (Dr. Uehara was supported as a Visiting Professor at Cornell by 211(d) funds).
- Wolf, J. Relaciones suelos-agua los laterolicos de Puerto Rico y Brasil. A paper presented at the Seminar on Soil Management and the Development Process in Tropical America at Cali, Colombia.

d. Processed Articles

- \*Abreu, R. E. 1973. Considerations for a cooperative soil survey in Venezuela. Cornell Univ. Professional Paper for the M.P.S. degree.
- \*Charreau, C. 1974. An outline of French research and development organizations for technical assistance in tropical countries. Cornell Agronomy Mimeo 74-15. 18 pp.
- \*Charreau, C. 1974. Origin and development of two Chadian tropical soil toposequences, biogeodynamic interpretation. Cornell Agronomy Mimeo 74-21. 16 pp.

- \*Cline, M. G., and Buol, S. W. 1973. Soils of the Central Plateau of Brazil and extension of results of field research conducted near Planaltina, Federal District, to them. Cornell Agronomy Mimeo 73-13. 43 pp.
- \*Dumith, D. A. 1973. Taxonomic considerations of some clayey soils of Venezuela. Cornell University Thesis for the M.S. degree.
- \*Forbes, T. R. 1973. Ferrallitic and ferruginous tropical soils of West Africa. Cornell Agronomy Mimeo 73-20. 34 pp.
- \*Lathwell, D. J. 1974. Report of the Caribbean and Tropical America Soils Conference at the University of West Indies, Trinidad, January 8-18, 1973. Cornell Agronomy Mimeo 74-7. 55 pp.
- \*Lathwell, D. J., and Cline, M. G. 1974. A report on the potential for collaboration of Cornell University with an institution in Ghana for extension of research under Contract AID/csd 2490 to Africa. Xeroxed.
- Ngongi, A. G. N. 1973. Tropical root and tuber crops: Factors affecting production and utilization. Cornell University Thesis for M.S. degree. 105 pp.
- Olson, G. W. 1973. A soils consultants photographs from Iran. Cornell Agronomy Mimeo 73-7. 27 pp.
- Olson, G. W. 1973. Outline of a course in soil survey interpretations in Venezuela. Cornell Agronomy Mimeo 73-14. 4 pp.
- \*Peech, M. 1973. Loss by leaching of adsorbed  $Ca^{++}$  from some highly weathered soils. Cornell Agronomy Res. Rpts., 1973. 2 pp.
- \*Ritchey, K. D. 1974. A partially annotated bibliography on manganese with special attention to the tropics. Cornell Agronomy Mimeo 74-16. 40 pp.
- \*Ritchey, K. D. 1974. A partially annotated bibliography on zinc in the tropics. Cornell Agronomy Mimeo 74-14. 22 pp.
- \*Weaver, R. M. 1974. Soils of the Central Plateau of Brazil: Chemical and mineralogical properties. Cornell Agronomy Mimeo 74-8. 45 pp.
- \*Wolf, J., and Drosdoff, M. 1974. Soil water properties of representative soils of Puerto Rico. Cornell Agronomy Mimeo 74-22. Approximately 61 pages.

3.4. Consultation: The activities reported here involved direct contributions to another institution or group by Cornell personnel and visiting scientists employed by Cornell. It includes contributions to conferences and meetings in which Cornell personnel actively participated as well as service to other institutions. In previous annual reports, linkages involving cooperative work with another institution and contacts made for the primary benefit of Cornell were included under this heading. The costs of these latter kinds of activities will be included under "consultation" in the financial report to be consistent with past practice, but the activities themselves are described separately in section 3.4a., which follows.

During the four years of the grant ending June 30, 1974, Cornell personnel have participated regularly in planning by the Consortium and in consultation with AID officials on activities concerned with the grant. Costs for these are reported under domestic consultation. In addition, Cornell personnel have provided service for the following domestic institutions and groups:

1. North Carolina State University - on research on soils of the tropics, 1971-72, 72-73. 7 man-days.
2. Soil Conservation Service - on taxonomy of soils of the tropics. 5 man-days.
3. Puerto Rico Agricultural Experiment Station - on soil research in Puerto Rico, 1970-71, 71-72, 72-73, 73-74. 20 man-days.
4. University of Puerto Rico and University of Hawaii - on experimental design for soil research in the tropics, 1973-74. 14 man-days.
5. AID - on project evaluation in Viet Nam, 1973-74. 14 man-days.
6. AID - on North Carolina State University soil testing project evaluation, 1973-74. 24 man-days.
7. AID - on drouth problems in the Sahelian zone of Africa, 1973-74. 1 man-day.

8. American Technical Assistance Corporation - on personnel for overseas assignment, 1973-74. 1 man-day.

Items 1 and 3 involved no 211(d) funds. All others involved part salaries of Cornell personnel on 211(d) funds, and items 2 and 7 were supported by 211(d) for travel.

During the four years of the grant, Cornell personnel have provided service to the following foreign institutions and conferences:

1. ICA, Colombia - on soil microbiology, 1971-72. 1 man, 5 man-days.
- \*2. Federal Experiment Station, Ministry of Agriculture, Km. 47, Brazil - on nitrogen fixation, 1970 to date. 3 men, 10 man-days.
3. Conference on Soil Research for the Tropics, IITA, Nigeria, 1971-72. 4 men, 20 man-days.
4. Division of Edofology, M.O.P., Venezuela - on organization and operations of soil survey of Venezuela, 1971-72, 72-73. 1 man, 10 man-months.
- \*5. Faculty of Agronomy, Universidad Centro-Occidente, Venezuela - on curriculum development for soil science, 1972-73. 1 man, 2 man-months.
6. Caribbean and Tropical America Soils Conference, University of West Indies, Trinidad, 1972-73. 1 man, 10 man-days.
7. Divisao de Pedologia e Fertilidad do Solo, Brazil, 1972-73. 1 man, 20 man-days.
- \*8. FAO, Rome - on soil survey interpretation, 1971-72. 1 man, 3 man-months.
- \*9. Soil Institute of Iran, Teheran - on soil survey interpretation, 1971-72, 72-73. 1 man, 6 man-months.
10. Nacional University Pedro Henriquez Urena, Dominican Republic - on soils and soil fertility, especially of the University farm, 1973-74. 2 men, 14 days.
11. Barbados - on soil fertility problems, 1973-74. 1 man, 5 man-days.
- \*12. International Biological Program, Kenya, 1973-74. 1 man, 7 man-days.
13. FAO/CIDA Regional Seminar on Shifting Cultivation, Ibadan, Nigeria, 1973-74. 1 man, 20 man-days.

- \*14. Instituto Agronomo Campinas, Brazil - applied soil microbiology, 1973-74. 1 man, 10 man-days.
- \*15. Polytechnic Institute, Mexico - on soil microbiology, 1973-74. 1 man, 3 man-days.
- \*16. Faculty of Agriculture, Israel - on environmental microbiology, 1973-74. 1 man, 7 man-days.
- 17. Limon Provence Development Project, Costa Rica, 1973-74. 1 man, 4 man-days.
- 18. Seminar on Soil Management and the Development Process in Tropical America, Cali, Colombia, 1973-74. 5 participants, 30 man-days.
- 19. CIMMYT, Mexico - on soil fertility considerations for plant breeding, 1973-74. 1 man, 7 days.
- 20. Federal Agricultural Research Institute, IPEAN, Belem, Brazil - on research on rice and cassava cultural systems, 1973-74. 1 man, 3 man-days.
- 21. EMBRAPA, Brasilia, Brazil - on cooperative research on soil fertility, 1973-74. 2 men, 9 man-days.
- 22. Soil Research Institute, Kumasi, Ghana - on cooperative soil fertility research project, 1973-74. 2 participants, 28 man-days.
- 23. CIDIAT, Venezuela - on plans for soils teaching, 1973-74. 1 man, 2 man-days.

Activities marked with an asterisk involved no 211(d) funds. All others except activity number 4 involved part salary of participants from 211(d) sources. Activities 1, 3, 4, 6, 7, 10, 11, 13, and 18 also had support for part or all of travel costs from 211(d) funds.

Consulting activities for 1973-74 are identified in the two lists. They aggregate about 208 man-days for the period, of which about 150 were foreign consultation, all except seven in LDC's.

3.4a. Linkages and Contacts: The term "linkage" is used for relationships that have involved direct participation of Cornell personnel in activities with scientists of other institutions. The linkages

identified include current relationships established through both presently active and past collaboration. The term "contact" is used for relationships of Cornell personnel with scientists of other institutions without direct participation in joint activities. The term implies more than normal correspondence or casual meetings between scientists. The linkages and contacts identified include those established both through 211(d) activities and under other auspices. Those that have involved 211(d) funding for part or all of the costs are identified by an asterisk.

A. Linkages

1. In the United States

- \*North Carolina State University
- \*Prairie View A&M University
- \*University of Hawaii
- \*University of Puerto Rico

2. In Other Developed Nations

- Food and Agriculture Organization of the United Nations
- \*British Ministry of Overseas Development
- \*University of Reading, England
- \*University of Oxford, England
- \*Institute for Tropical Agronomic Research and Crop Culture (IRAT), France
- \*Office of Scientific Research and Technology Overseas (ORSTOM), France

3. Southeast Asia

- College of Agriculture, University of the Philippines, Los Banos
- International Rice Research Institute (IRRI), Philippines

4. Africa

- \*International Institute of Tropical Agriculture (IITA), Nigeria
- \*Soil Research Institute, Ghana

5. Latin America

- \*Division of Pedology and Soil Fertility, Brazil
- EMBRAPA, Brasilia, Brazil
- Federal Experiment Station, Km. 47, Brazil
- Federal Agricultural Research Institute, IPEAN, Belem, Brazil

- \*National University Pedro Henriquez Urena, Dominican Republic
- \*Division of Soils, M.O.P., Venezuela
- \*International Center for Tropical Agriculture (CIAT), Colombia
- International Center for Improvement of Rice and Corn (CIMMYT), Mexico

## 6. Middle East

Soil Institute of Iran, Teheran

During 1973-74, Cornell personnel participated directly in activities with personnel of the following institutions identified above.

1. The four Universities of the soils consortium, in
  - \*(a) A Seminar on Soil Management and the Development Process in Latin America, Cali, Colombia
  - \*(b) A Workshop on Soil Mineralogy, Hawaii
  - \*(c) Development of a Directory of Soil Scientists for Tropics
  - (d) A Conference on Experiment Design for Soil Research in the Tropics, Hawaii
  - (e) Soil fertility research in Brazil, with North Carolina State University
  - (f) A winter field laboratory on problems of agriculture in the tropics for Cornell students, with the University of Puerto Rico
  - \*(g) Activities of Professor Uehara of the University of Hawaii as Visiting Professor at Cornell for four months.
- \*2. IRAT and ORSTOM, France, in activities of Dr. Claude Charreau as Visiting Professor at Cornell for six months.
- \*3. IITA, Nigeria, in (a) a study of cropping systems and the potential for food crop production on a soil climosequence in West Africa by a graduate student, (b) work on a test for nitrogen supplying power of soils, and (c) plants for soil fertility research in Ghana.
4. The Soil Research Institute, Kumasi, Ghana, in a study of the potential for cooperative research at the Institute and plans to initiate that project.
5. EMBRAPA, Brasilia, Brazil, in soil fertility research for the Central Plateau of Brazil.
6. The Federal Agricultural Research Institute, IPEAN, Belem, Brazil, in research on rice and cassava mixed cropping systems.
- \*7. The National University Pedro Henriquez Urena, Santo Domingo, Dominican Republic, on (a) soil fertility research plans and (b) a winter field laboratory for Cornell students.
8. CIAT, Colombia, on research of two graduate students on (a) rhizobium and inoculation of legumes in the tropics and (b) nutrition of cassava.

9. CIMMYT, Mexico, on preliminary plans for an interdisciplinary research project on corn production on small farms by eight graduate students.

## B. Contacts

### 1. In the United States

Relationships are maintained with scientists of many institutions, including casual contacts about matters pertaining to international development and personnel for overseas work. These are considered part of normal operations and are not listed separately.

### 2. In Other Developed Nations

\*Belgian Cooperative and Development Office, Brussels  
\*University of Ghent, Ghent, Belgium

### 3. Southeast Asia

Soil Research Institute, Bogor, Indonesia

### 4. Africa

\*University of Ibadan, Ibadan, Nigeria  
\*Institute for Agricultural Research and Ahmadu Bello University, Samaru, Nigeria  
\*University of Science and Technology, Kumasi, Ghana  
\*University of Ghana, Legon, Ghana  
\*Crops Research Institute, Kumasi, Ghana  
Council for Scientific and Industrial Research, Accra, Ghana  
\*IRAT Research Center, Bouake, Ivory Coast  
\*IRAT Agricultural Research Center, Bambey, Senegal  
\*ORSTOM Center, Dakar, Senegal  
Makerere University, Kampala, Uganda

### 5. Latin America

Institute of Agronomy, Campinas, Brazil  
\*University of West Indies, St. Augustine, Trinidad  
Interamerican Center for Integral Development of Water and Land Resources (CIDIAT), Merida, Venezuela  
University of the East-Central Region, Venezuela  
\*Division of Integrated Studies of Natural Resources, Lima, Peru  
National Center for Agricultura Research, Bogota, Colombia  
Polytechnic Institute, Mexico

In addition to the 12 LDC's for which linkages and contacts are listed above, graduate students of the past four years provide contacts

in the following countries:

Cameroon	Korea
Ceylon	Malawi
Chile	Malaysia
Ethiopia	Pakistan
Honduras	Taiwan
India	Thailand
Jamaica	Uruguay

Contacts in the preceding list which were established during 1973-74

include:

The Soil Research Institute, Bogor, Indonesia through consultation with Dr. D. M. Muljadi, Director, on Cornell's international program and soil fertility research in the tropics.

The Council for Scientific and Industrial Research, Accra, Ghana, through consultation with Dr. Tackie, Executive Chairman, concerning cooperative research by Cornell and the Soil Research Institute of Ghana.

Contacts were renewed during 1973-74 with ten of the nineteen other institutions listed, either by visits to the institution by Cornell scientists or by visits of scientists from the institution to Cornell.

3.5. Library and Reference: The Cornell University library system ranks between eighth and twelfth by various measures among University libraries of the United States and contains an exceptional collection on agriculture, including the tropics. Few items needed during the life of the grant have been unavailable in it. Consequently, the effort under the grant has been to increase critical holdings in the working library of the Agronomy Department. Emphasis for acquisitions has been placed on series that emphasize soils, such as the Soil Resource Bulletins of FAO and bulletin series of institutions with which Cornell maintains linkages and contacts. New books are ordered as they appear. Acquisitions

of this kind aggregate about 400 volumes to date.

A set of cards listing the main holdings of the Cornell University Libraries on soils and agriculture of the tropics has been prepared and inserted in the Agronomy card catalogue and is indexed by countries. A separate file lists holdings in the Agronomy library.

Considerable effort was expended on investigation of bibliographical services and retrieval systems for soils of the tropics for the Consortium. It was concluded that service of this kind is beyond the resources and expertise of the Consortium and that existing and projected services and systems on a national scale can satisfy most needs if institutions take advantage of them. A project was undertaken by Cornell acting for the Consortium to assemble and publish a bibliography of soils of the tropics consisting of some 12,000 references held by the Soil Conservation Service.

Cornell has also been active in developing a directory of expertise in soil science for the tropics as part of a Consortium effort.

During 1973-74, approximately 100 items were acquired for the Agronomy library collection, mainly by contributions from the publishing institutions. These include a collection of the publications of ORSTOM, IRAT, and other French institutions contributed by Visiting Professor Charreau

A consultant has assembled that part of the bibliography of soils of the tropics dealing with general subjects and most of West Africa. His work will continue for the rest of the tropics during 1974-75.

Cornell has mailed questionnaires for biographical data of soil scientists for the tropics to about 400 individuals and institutions in Latin America and Africa. Questionnaires were sent in English, Spanish, and Portuguese, as appropriate, to encourage response. The first responses have been received. As they are received they will be forwarded to Prairie

View A&M University, which is responsible for the final publication of the directory. Visiting Professor Charreau has agreed to obtain biographical data for soil scientists of Francophone Africa on his return to Paris.

Nine reference documents have been issued and distributed in quantity to AID, other institutions, and selected individuals during 1973-74. These are listed in the section on Publications and Manuscripts under "Processed Articles" as "Agronomy Mimeos."

4. Impact of Grant-Supported Activities in Developing Institutional Capabilities: No attempt is made here to separate the impact of the contract for soil fertility research in the humid tropics (AID/csd 2490) from that of the 211(d) grant (AID/csd 2834). The two have run concurrently. Both have contributed to faculty experience and competence. The research contract, however, has involved mainly six faculty members, four of whom had had substantial experience with tropical soils when the project started. Impact on the competence and commitment of other faculty, and some of the expertise of these six must be attributed to the 211(d) grant.

The numbers of faculty members who have expertise and commitment for soils and agriculture of the tropics have increased from six in 1970 to sixteen in 1973-74. In terms of full-time man equivalents (FTE), this represents an increase from about 2.5 FTE prior to initiation of the grant to 5.6 FTE in 1973-74. The faculty involved and the subjects they represent follow:

D. R. Bouldin - Soil fertility	0.2 FTE
D. J. Lathwell - Elementary teaching and fertility research	0.3 FTE
T. W. Scott - Elementary teaching and fertility research	0.5 FTE
M. Peech - Soil chemistry	0.1 FTE
M. Alexander - Soil microbiology	0.1 FTE
R. W. Arnold - Soil genesis and classification	0.2 FTE
W. S. Reid - Soils extension	0.1 FTE

G. W. Olson - Soil survey interpretation	0.1 FTE
P. J. Zwerman - Soil and water management	0.1 FTE
G. Levine - Soil and water engineering (Agr. Engineering)	0.1 FTE
R. B. Musgrave - Crop ecology - soils relations	0.1 FTE
R. M. Weaver - Soil mineralogy	1.0 FTE
M. Drosdoff - Soils of the tropics	1.0 FTE
M. G. Cline - Soil genesis and classification	0.5 FTE
R. H. Fox - Soil fertility research (Puerto Rico)	1.0 FTE
H. A. MacDonald - Tropical agriculture	0.2 FTE
	<u>5.6 FTE</u>

All have had experience in the tropical environment, and thirteen of the sixteen have spent at least a year of full-time assignment in the tropics. This cadre of faculty is a resource of expertise representing all of the major areas of soil science.

Cornell has established contacts and linkages with 29 institutions in LDC's, exclusive of connections in 14 other countries through graduate students. These relationships are important elements of institutional capability for both development and maintenance of expertise and the potential for bringing that expertise to bear on problems of LDC's. The contacts and linkages with international programs of four institutions of the United States and six international institutions of other developed nations augment this capability.

The research activities summarized under "Accomplishments" have not only had a major and lasting impact on the expertise of faculty but also have enhanced the knowledge base of the institution. The publications arising from them are resources that increase institutional capability for teaching, research and consultation. Library resources also represent a substantial asset that was less easily accessible prior to the grant.

Authorization to fill a full-time position on a State salary item for continuing work with soils in the international program of the College

is a major contribution to institutional capability for the foreseeable future. This fulfills an obligation for continuity beyond the life of the 211(d) grant. It insures continuing involvement of the Department for the purposes of the grant and reflects the institutional commitment to those purposes.

5. Utilization of Institutional Resources in Development: Over the four years that the grant has been in effect, Cornell faculty have spent approximately 575 working man-days in a consulting capacity with institutions of LDC's, exclusive of conferences, seminars, and training institutes. Seventy man-days were spent in this capacity during 1973-74. An additional 40 man-days were spent in consultation with or for AID on problems of LDC's at no expense to AID except for travel.

Seventy-one graduate students from 24 developing nations and the United States, Canada, and the Netherlands have been in training for development work in LDC's over the life of the grant. Thirty-nine of these were still in training during 1973-74. This is by far the most significant use of institutional resources from the standpoint of total impact that can be expected in LDC's.

One Assistant Professor, one Research Associate, and two Graduate Assistants were stationed overseas during 1973-74 on funds of AID research contract csd 2490. This project, though funded independently of the 211(d) grant, uses institutional expertise for solution of soil fertility problems of developing nations. Seven graduate students, in addition to those supported by this contract, conducted research in five LDC's on problems of soils and agriculture in the respective developing countries.

6. Other Resources Used for Grant-Related Activities: The value of resources contributed to the 211(d) program, exclusive of all AID funds, averaged \$114,600 per year for the first three years of the grant. This is about \$7000 per year more than support from 211(d) funds. This amount includes estimated salaries and wages, supplies and services, communications, and travel from New York State appropriations and other funds administered by Cornell. It includes direct support of faculty and students from outside sources for activities directly related to the 211(d) program but does not include outside support for foreign or domestic graduate students who were not directly involved in 211(d) activities. It also includes indirect costs and fringe benefits contributed by Cornell for employees whose salaries came from 211(d) funds.

Cornell contributions exclusive of AID funds for 1973-74 amount to about \$128,000. Details are given in the financial report for 1973-74, which is to be submitted separately. They are larger in proportion to 211(d) expenditures than in previous years, however, as unusual budgetary circumstances permitted almost the entire cost of the project for two months to be borne by other funds. Net expenditures from 211(d) funds for the February and March expenditure summaries, therefore, were only \$1467 compared to normal monthly expenditures of \$8000 to \$9000.

7. Next Year's Plan of Work:

7.1. Teaching: Teaching activities described for 1973-74 will continue during 1974-75 with the exception of the special summer session course for students with nonagricultural backgrounds. Participation in 1973-74 was not great enough to justify continuation. The course on Cultural Systems for Tropical Soils will be taught during the fall semester

1974. Professor Fox, who is stationed in Puerto Rico, will be brought to the Ithaca campus on 211(d) funds to teach it. The informal seminar, Tropical Soils Discussions, has been highly successful and will be continued with Visiting Professors responsible for most of the sessions.

Dr. P. H. Nye of Oxford University, an authority on cropping systems in the tropics and ion equilibria in soils, will serve as Visiting Professor from August 15 to December 15, 1974. Sr. Marcello Camargo, Chief of the National Soil Survey of Brazil, will be Visiting Scientist during September. His services will be shared with North Carolina State University and the University of Puerto Rico. It is planned that during the spring term Dr. Eshel Bresler, head of the Soil Physics Department at the Volcani Center in Israel, will give a series of lectures on water management in the dry tropics and subtropics. He will be supported in part by 211(d) funds. Plans are still not firm for Dr. Collins of Prairie View A&M University to spend the spring semester at Cornell.

If the Tropical Soil Institute for soil scientists of Southeast Asia, which was cancelled in 1973-74, is held, Cornell faculty will participate, as they will in any seminar or conference planned by the Consortium as a continuation of the series held in Nigeria in 1972 and Colombia in 1974. At a meeting of the executive committee of the Consortium held in April, 1974, endorsement was given to a proposal for Institutes or Workshops to be held under the Consortium sponsorship on the subject: "Recent Advances in Tropical Soil Science: Soil Classification for Resource Evaluation" at suitable locations in the following regions:

Latin America - April or June 1974

Asia - September or November 1974

Africa - February or April 1976.

Also the Consortium accepted the offer of the University of Hawaii as the site and responsible institution for conducting a course in Tropical Agronomy requested by the International Agronomy Division of the American Society of Agronomy. The other overseas teaching activity planned is the January, 1975, field studies in the Caribbean in conjunction with Cornell's interdepartmental course on Special Studies of Problems of Agriculture in the Tropics.

7.2. Research: Work will continue on the problems of items 3, 4, 5, 6, 7, 8, and 9 for which 1973-74 progress is reported in the last part of section 3.2. These will continue to receive significant 211(d) support. The work on nutrition of cassava in Colombia and on mixed cropping systems in Brazil, which received no AID support in 1973-74, will also continue with independent sources of funds. In addition, work on limiting soil factors as criteria for maize breeding will be initiated at CIMMYT as part of an interdisciplinary project supported independently of AID sources. A project to evaluate the predictive value of ERTS satellite imagery for soil survey objectives in the tropics will be initiated, with testing against the ground truth available in Puerto Rico. This will be supported by 211(d) funds. Activities of soil fertility research under contract AID/ta-c-1104 is expected to be extended to Ghana, with no 211(d) input for contract objectives.

7.3. Publications: Primary emphasis will be placed on three items: (a) Publication of the technical manuscripts accepted and prepared for publication as listed under 3.3 of the section on accomplishments, (b) publication of the lectures by C. Charreau on soils and cultural systems of the African Sahelian zone, and (c) publication of the bibliography of soils of the tropics from files of SCS, currently being assembled by a consultant. Other technical articles on research now under way are anticipated.

7.4. Consultation and Linkages: Activities are expected to concentrate on development of plans and linkages for formalizing the Consortium and extending its expertise to LDC institutions. The Consortium is exploring with AID officials the possibilities for revision of the institutional grants upon termination of the present grants. Revised programs for the Consortium as a whole and for the individual Universities are under consideration. A tentative outline of a plan for institutional linkages and collaborative arrangements with LDC's was formulated at the Spring 1974 Meeting of the Consortium executive committee and was discussed at a later meeting of the Council of Deans with representatives of AID. If the plan is developed fully as a formal proposal for AID funding, a considerable amount of time and effort will be required during 1974-1975 to complete the details.

The tentative plan would establish a Consortium headquarters with specified functions. All of the Consortium institutions would be involved in the planning and recruitment of staff. The plan also calls for the establishment by each of the individual Consortium members of a linkage with institutions in two or three LDC's with a specific objective of working

jointly with each to solve important soils problems in the country's agricultural development programs. This would involve intensive consultation with the LDC institution to develop plans and establish the necessary agreement for implementing the problem solving operations. Advance consultation with AID officials both in Washington and in country missions would be required to select appropriate countries, institutions, and key problem areas.

7.5. Library and Reference: In addition to normal acquisitions of relevant material for the Agronomy Library, major emphasis will be placed on completing the bibliography of soils of the tropics now held by SCS in a form for publication, and on the canvass for biographical data for the directory of soil scientists for the tropics that is being assembled for the Consortium by Prairie View A&M University.

8. Other: Recruitment of a qualified soil scientist to fill the soils position as leader of the international soils program in the University will be pursued vigorously. It is essential that this position be filled before the retirement of Professor Drosdoff in 1975.

9. Report of Expenditures: By consent of AID authorities, the financial reports of Consortium members will be submitted as separate documents. This is being done because official financial statements of University transactions are not available in time to permit development and distribution of this narrative report by the time it is needed for review in AID.

REPORT OF  
UNIVERSITY OF HAWAII



## REPORT OF UNIVERSITY OF HAWAII

## FOR THE PERIOD

JULY 1, 1973 TO JUNE 30, 1974

A. TITLE: A Grant to Strengthen the Capabilities of the University of Hawaii in Special Problems of Tropical Soils (Grant AID/CSD 2833)

B. GRANTEE: University of Hawaii

C. DIRECTOR: Dr. Wallace G. Sanford

D. STATISTICAL SUMMARY

1. Period of Grant: November 2, 1970 to November 2, 1975

2. Amount of Grant: \$500,000

3. Expenditures

3.1 For report period: \$198,800

3.2 Accumulated: \$478,000

3.3 Anticipated for next year: \$20,000

E. NARRATIVE SUMMARY

The objectives of this grant are to strengthen the existing competency of the University of Hawaii by collaborating with the members of the Consortium. To this extent, several Hawaii faculty members have gone on sabbatical leaves not only to increase their competency but also to extend the expertise and experience of Hawaii to other institutions. Several faculty members from other institutions have also come to Hawaii to work in their area of specialization and to engage in the exchange of ideas.

The contribution to soil mineralogy by the University of Hawaii was presented to the members of the Consortium when a soil mineralogy workshop was held in Hawaii during July, 1973.

Funds have been used to hire research personnel and graduate students to conduct research which will enhance the capability of

the University in tropical soils for teaching, further research, service, and consultation. At the completion of a study, most of the findings have been published in journals or as theses or dissertations or have been presented in a seminar or symposium.

Funds have also been used to provide travel for several individuals to increase their knowledge of tropical soils other than in Hawaii. At the same time, these individuals were able to see and sometimes to suggest the possibilities of applying what is known in Hawaii to other parts of the tropics.

A summary of the activities at the University of Hawaii shows that continuous efforts are being made to up-grade the undergraduate teaching. Illustrated concepts pertaining to tropical agriculture are still being published and a laboratory manual has been revised for classroom use. In microbiology research, nitrogen fixation and biological activities in soils are being studied. In soil mineralogy, emphasis is being placed in developing research techniques, for example, by use of the X-ray quantometer, to understand the role of minerals in imparting special behavior in tropical soils. Chemical and physical properties of soils are also being investigated in great detail. Soil characterization and classification are used to determine which of the soils have similar behavior and thus aid in soil interpretation. Finally, emphasis is being placed on the management of soils by conducting soil fertility experiments.

#### F. DETAILED REPORT

1. General Background and Purpose of the Grant: In making this grant, the principle criterion used was the degree of commitment a university is making or willing to make in increasing its competence

in tropical agriculture. Development of this competence would lead to a better understanding of significant agricultural problems relevant to emerging nations in the tropics. To this end, AID awarded five-year grants to establish centers of competence in tropical agriculture at existing institutions with permanent sources of funding and commitments on problems of international development.

## 2. Objectives of the Grant

2.1 Objectives restated: This grant will strengthen the existing competency of the University of Hawaii by means of a collaborative effort with Cornell University, North Carolina State University, Prairie View A&M College, and the University of Puerto Rico, to provide training, related research, technical assistance and consultation, and conduct related research in soil science for increasing food production in soils of the tropics. The grant will be used to:

- (1) Further strengthen the soil mineralogy group at the University by the addition of a soil mineralogist, a technician, and appropriate support and equipment
- (2) Provide for visiting professorships to be used to bring the University of Hawaii additional expertise and experience from either the cooperating institutions or from other services
- (3) Provide graduate assistantships in order that students of the other four cooperating institutions may have access to the special strength of Hawaii
- (4) Provide graduate assistantships to conduct research in tropical soils toward advanced degrees at the University of Hawaii

- (5) Provide funds for travel by assistantships that are exchanged among the institutions, for visiting professorships, and for staff to consult with other cooperating institutions
- (6) Strengthen the existing curriculum in tropical soils so that it will be more useful to AID and other personnel involved with tropical soils, crop management, and other related activities in the less-developed countries
- (7) Strengthen library and other information services with special emphasis on the preparation of manuals or other training materials on tropical soils and other related fields

2.2 Review of the objectives: The objectives listed above will remain essentially the same except more emphasis will be placed on extension work particularly when such work, is compatible with the work being done in teaching and research. In meeting the fulfillment of this objective, section 5 of this report should be perused. In the future, individuals traveling to other areas whether on 211(d) or other funds, will continue to make available their services as experts when requested by appropriate individuals.

### 3. Accomplishments

3.1 Teaching: Continuous efforts were made to up-grade the undergraduate courses in introductory soil science: "Soils and Man" and "Tropical Soils" taught by R. E. Green and H. Ikawa, respectively. Results of student evaluations conducted by the Office of Academic Development showed positive progress. In addition to the basic principles of soil science, special considerations were given to current problems, such as environmental concern, in both of these courses. Further improvements are being considered when a College Learning Center becomes available for expansion of the audio visual tutorial programs associated with these courses. An increase in class enrollments in these courses suggests that more students outside the College of Tropical Agriculture are beginning to enroll in these agricultural courses.

During the fall semester, the graduate course in soil formation and classification was offered by A. R. Southard, Professor of Soils at Utah State University, who is spending his one-year sabbatical leave at the University of Hawaii from August 1973 through August 1974. In addition to 13 registered students, several faculty members and other students attended the lectures. The students had opportunity to go on several field trips to study soil properties and to describe soil pedons.

Two "Illustrated Concepts in Tropical Agriculture" were prepared and published during 1973 by R. L. Fox. These are used as handout materials for classroom use and to acquaint visitors and others with special features of tropical agriculture. The two concepts deal with the N and irrigation control for producing quality sugarcane and the adverse influence of low soil temperature on nutrient uptake by pineapple.

The soil physics laboratory manual prepared by G. Y. Tsuji and L. T. Santo during the last fiscal year was revised. This manual will serve as the basic reference for measurement and characterization of physical properties of most Hawaiian soils.

3.2 Research: In the area of soil microbiology, a project was undertaken by Jean Oya, graduate student partly supported by 211(d) grant, under the guidance of B. L. Koch, to evaluate the rate of non symbiotic nitrogen fixation in select pasture soils of Hawaii. Attempts are being made to relate various environmental factors to rates of nitrogen fixation, population of nitrogen-fixing organisms, and overall microbial population. Several aerobic and facultative anaerobic bacteria capable of nitrogen fixation have been isolated, and it is likely that identification of these organisms will result in new bacteria previously not considered to fix atmospheric nitrogen.

Analytical techniques for the isolation and identification of the herbicide diuron and its metabolites from soil and culture are being developed by V. Elder, graduate student, also under the direction of B. L. Koch. These techniques include the development of thin-layer and gas chromatograph procedures. Once perfected, these procedures can be used to study degradation of diuron in Hawaiian soils.

The X-ray quantometer which is used for total analysis of rock, soil, and plant samples is now in operation under the guidance of project leader R. C. Jones and Junior Researcher E. N. Okazaki. Jr. Researchers A. Chang and A. Chu, graduate students G. W. Gribble, W. H. Hudnall, and J. Braide and several student-help are also employed in this project under the 211(d) grant. Considerable progress has been made in calibrating the instrument by using primary or secondary standards of rocks obtained from the USGS, the Japan Analytical Laboratory and the Hawaii Institute of Geophysics. Clay minerals, kindly furnished by S. B. Weed of North Carolina State University, were also used.

The Hawaii quantometer can be used to obtain the total analysis of rocks, soils, and minerals in the following concentration ranges:

SiO <sub>2</sub>	36.01 - 78.93%	CaO	0.24 - 24.44%
Al <sub>2</sub> O <sub>3</sub>	6.77 - 37.16	MgO	0.04 - 29.98
Fe <sub>2</sub> O <sub>3</sub>	0.79 - 29.87	Na <sub>2</sub> O	0.11 - 8.35
TiO <sub>2</sub>	0.12 - 3.03	K <sub>2</sub> O	0.09 - 10.68
MnO	0.01 - 1.65	P <sub>2</sub> O <sub>5</sub>	0.01 - 1.09

In his study, Gribble has shown that if the concentrations of the above oxides are within the calibration ranges, the results of the analysis is within one percent or less of the reported concentration.

Improvement in the results for concentration outside of the calibration ranges for these 10 oxides are now in progress. Special emphasis is being made to obtain a higher concentration of Fe<sub>2</sub>O<sub>3</sub> and a lower concentration of SiO<sub>2</sub>. The cost of the total analysis of the 10 oxides of a sample ranges from \$150 (Japan) to \$200 or more (U.S.). The same analysis can be performed on the Hawaii quantometer at an estimated cost of \$20 per sample; 20 samples per week.

Mineral characterization and allocation of soil samples can be performed at the University of Hawaii by utilizing the combined data obtained by X-ray diffraction analysis, electron microscopy, and total analysis by quantometer. Sixty-six horizons of 11 pedons from Puerto Rico were examined recently by Hudnall.

Although still experimental, the use of the quantometer's scanning spectrometer is being investigated to determine the coordination number of Al in crystalline and non-crystalline inorganic materials. Such a technique can indicate Al substitution of Si in the silica tetrahedral positions in minerals and the source of net negative charge in these minerals.

Progress has also been made during the past year in calibrating the quantometer for plant tissue analysis. The developmental procedure was similar to that used for rock, soil, and mineral analysis; that is, secondary standards were used to calibrate the instruments. These standards were based on results obtained by atomic absorption, colorimetry, flame photometry, turbometric analysis, and/or gravimetric analysis. Standard curves for plant tissue have been developed for the following concentration ranges:

Mg	0.04 - 1.21%	K	0.44 - 9.05%
Al	30 - 800 ppm	Ca	0.08 - 5.68%
Si	0.02 - 1.38%	Mn	4 - 1185 ppm
P	0.055 - 0.872%	Fe	19 - 514 ppm
S	0.01 - 1.66%	Cu	2 - 76 ppm
Cl	0.32 - 2.46%	Zn	8 - 200 ppm

These concentration ranges were established for macadamia leaf, papaya petioles, sugarcane sheath, pangola and kikuyu grasses, corn leaf, pineapple leaf including the basal whites, iceberg lettuce, chinese cabbage, cucumber leaf, and tomato leaf and petiole. Extension of the standard curves and the addition of other plant tissues are planned.

Plant root simulation by use of cation and anion exchange resins is progressing satisfactorily; quantometer calibration curves have been developed by Braide for the uptake of Na, Mg, Al, K, Ca, Mn, Fe, Cu, Zn, and Mo by cation exchange-impregnated filter discs. These discs, after being equilibrated with the salt solution of the respective cations, were washed, freeze-dried, and analyzed by means of the quantometer. These results were correlated with the results obtained by atomic absorption

after the same discs were ashed and the elements were taken up into solution. Plans are underway to investigate ammonium acetate extract by a similar procedure.

The Alfisols and Ultisols of Hawaii are being studied by A. R. Southard, Visiting Professor of Soils from Utah State University, with interests in soil genesis and classification.

Study of these soils will reveal why Alfisols occur in Hawaii in relation to the occurrence of Ultisols and some other soils. The study of Ultisols will provide more data for soil interpretation and subsequently recommendations for land use. The field work and sampling has been completed for Oahu by Southard, G. Y. Tsuji, H. Ikawa, S. P. Periaswamy and others, and laboratory characterization of the soils is now in progress.

Field observations in numerous locations on Windward Oahu revealed the presence of materials with a smeary consistence in both soils and saprolyte. This material is yellow (10 YR 5/6) and gray (5Y 4/1). Associated red material (10 R 4/6) is usually not smeary. These smeary materials have low bulk densities of less than 1.0 g/cc and particle densities range from 3.0 - 4.2 g/cc. The mineralogy by X-ray diffraction analysis shows the presence of Fe, Ti, and Al oxides with goethite and gibbsite being most common. After heating to 105°C, these materials still retain the smeary consistence and can be rewetted to 60-100% moisture by weight. At these moisture contents, the material has low shear strength. Waikane and Lolekaa (Tropohumults) soils which contain weathered gravels with smeary consistence, retain 40-50% by weight at 15-bar tension. These soils show tendencies to slip on moderate to steep slopes. The importance of the behavior of these soils in watersheds and construction sites needs investigation.

The influence of soil micro structure on the water release characteristics of several soils were examined by G. Y. Tsuji, R. T. Watanabe, and W. S. Sakai. Intra-aggregate voids, viewed under the scanning electron microscope, were prominent in the Molokai (Typic Torrox), Wahiawa (Tropeptic Eutruxox), Manana (Orthoxic Tropohumults), and Paaloa (Humoxic Tropohumults) soils. The high water holding capacity of these soils at high suction was attributed to these voids. In the lower suction range of 0-200 cm, the influence of the interaggregate voids is most pronounced. The role of soil water hysteresis in this range is the subject of an M.S. thesis by L. T. Santo who is supported by the 211(d) grant. A 5-7% difference in water content was found between the absorption and desorption water release curves for the Molokai and Wahiawa soils.

An M.S. thesis research on the zero point of charge of soils differing in mineralogy was completed by J. C. Keng, also supported by the 211(d) grant. It was concluded that the majority of the soils in Hawaii have minerals which behave as colloids of the constant potential type. Soil minerals in this category include oxides and hydrous oxides of Fe and Al, kaolinite, halloysite, and non-crystalline hydrous oxides. Constant potential type colloids were distinguished from the constant charge type, such as those with montmorillonitic mineralogy, through potentiometric titration and determination of the existence of non-existence of a well-defined zero point of charge; i.e., the point of intersection of the titration curve.

Data collection by Tsuji on the vertical water infiltration has been completed and the analysis of the data is being made. Tsuji, together with S. Wann, who is supported by 211(d) grant, are also involved in a cooperative study with Southard and Ikawa in characterizing and correlating selected soils in Hawaii.

Studies on the nature of solute movement in Oxisols and Hydrandepts were continued by R. E. Green. Laboratory column measurements of displacement of aqueous solutions of tritiated water, chloride, picloram (herbicide), and methanol provided an assessment of the fraction of soil water in the soil which actively participates in solute movement. Solute dispersion in moving water determines the distribution of fertilizers and herbicides in the soil under different irrigation regimes. Inter-aggregate water in Oxisols is highly mobile, but all intra-aggregate water was also found to participate in solute movement. In an Hydrandept containing over 200% water by weight at field capacity, only 10% of the water was found to be non-solvent in character; the exclusion of solutes from this water was indicated principally by displacement of an aqueous methanol solution through the soil in a miscible displacement experiment. Current work includes testing various mathematical models designed to describe the effects of soil structure (pore geometry) on solute dispersion.

A field experiment was conducted on the Molokai (Typic Torrox) soil to determine the distribution of two soil-applied herbicides and nitrate under trickle irrigation. Soil-water tension during and between water applications was monitored by tensiometers spaced at regular intervals in two dimensions (vertically in the soil profile and horizontally perpendicular to the irrigation line) with the origin at the emitter. A graphical plot of equal total-potential lines provides a description of water flow direction at various times. Water flow will thus be related to the solute distribution in the soil as determined by analysis of solutes in samples of soil water obtained from ceramic-cup samplers placed in the soil. Changes in the soil structure with depth and the presence of a "plow pan" at the top of the B horizon are expected to have important effects on water and solute distribution in the soil profile. M. Furukawa, graduate assistant supported by 211(d) grant works on this experiment.

Nitrogen transformation and adsorption studies were made by Y. Kanehiro and V. Balasubramanian, a graduate student supported by 211(d) grant (Jan. 1 - Mar. 31, 1974). Of two liming materials, calcium carbonate was found to be more effective than calcium silicate in increasing ammonium adsorption and decreasing nitrate adsorption in two Hydrandepts (Hilo silty clay loam and Akaka silty clay) and in one Gibbsihumox (Hali gravelly silty clay). The former compound was also more effective in raising soil pH than the latter. At around pH 5.5, the limed soils began to repel nitrate. For the same pH in limed soils, the Hydrandepts showed a higher affinity for ammonium than the Gibbsihumox. This is most likely due to the high surface areas available for adsorption in the Hydrandepts.

In a denitrification capacity study, a special incubation apparatus was designed to monitor the process periodically without disturbing the inside atmosphere of the soil incubation flask. Under controlled conditions in the complete absence of oxygen, about 40-70% of the applied nitrogen (application rate of 30 mg  $\text{NO}_3\text{-N}/100$  g soil) was lost as nitrogen and nitrogen oxide gases in two Hydrandepts. A Chromustert (Lualualei clay) was similar in denitrification capacity to the Hydrandepts, while a Torrox (Molokai silty clay loam) and a Tropohumult (Paaloa silty clay) showed low capacities. A readily available energy source appears to be the most important factor in denitrification; moisture and soil pH are also important.

Organic matter incorporation and decomposition studies were also conducted by Y. Kanehiro and M. Asghar, a graduate student partly supported by the 211(d) grant. A survey of organic matter status in soils was carried out by collecting samples from cultivated and virgin areas on the island of Oahu. Percent organic matter was invariably much higher in virgin as compared with cultivated soils, C/N ratio was also higher in virgin than in cultivated soils. Soil pH of cultivated fields was generally lower than that of adjacent virgin soils. Phosphorus fertilizer requirement was generally higher for cultivated than for virgin soils. Electrical conductivity of saturation extract was found to be above 4 mmhos/cm in some cultivated soils.

Effects of lime on legumes were investigated by D. Munns, Visiting Professor from the University of California at Davis, who is supported by the 211(d) grant. The lime response of 25 tropical and temperate crop and forage legumes were compared on an Oxisol containing high amounts of Mn. The trial had a 4-replicate continuous function design covering a pH-span from 4.7 to 7.2. Observations are being made on growth and yield, nodulation, nitrogen fixation (acetylene reduction), mineralization of soil nitrogen, and the availability and uptake of P, Ca, and Mn. The most striking result 6 weeks after planting is the lack of any large benefit from lime in Glycine max or representatives of the genera Stylosanthes, Desmodium, Lotus, Vigna, Arachis, Leucaena, or Acacia. Some benefit is evident in Trifolium subterraneum and considerable benefit in T. repens, Medicago sativa, Dolichos axillaris and a Glycine wightii cultivar. Diversity of response appears to be the rule, cutting across groupings as to taxonomy or tropical vs temperate origin. Above pH 5.5-6.0, liming depresses nodulation and acetylene reduction in most species. In some species, growth is also depressed. Such an observation supports existing evidence that liming

of highly weathered soils much above pH 5.5 is likely to be not only expensive but also damaging to crop performance.

The immobilization and desorption of phosphate in tropical soils were also studied by Munns. In laboratory studies, the apparent hysteresis becomes much smaller with time (months) following the addition of phosphate to the soil, indicating that non-equilibration is partly responsible for the large hysteresis observed early after phosphate addition, when immobilization is proceeding rapidly. The rate of the slow immobilization process at any one time appears to be a linear function of phosphate in solution (first order), but the rate constant declines with time. Liming of the soil has had little effect on the immobilization rate except by strongly enhancing the initial sorption of phosphate. Immobilization is proceeding faster in an Andept and a Gibbsumox than in the less-reactive Ustox. Drying to -15 bars potential has had no important immediate effect of phosphate solubility. Long term data are not yet available.

In another soil fertility project, the study of the use of phosphate sorption isotherms for determining immediate and recurring phosphate fertilizer requirements were continued by R. L. Fox, with the aid of a technician partly supported by <sup>the</sup> 211(d) grant. The emphasis was on determining the internal and external P requirements on different varieties of the same species of plant. The general conclusion is that the external P requirement (the concentration of P required in the soil solution) is similar for two varieties of the same crop growing in the same soil or for the same variety growing in different soils (within the range of soils investigated), although the internal P requirement (the concentration of P required in the plant) can be very different for two varieties growing at the same location at the same time. Different species have different external and internal P requirements. For example, the external

requirement for grain sorghum is about 0.05 ppm P in solution and for chrysanthemum is about 0.2 ppm. The internal requirement for chrysanthemum for two varieties was 0.36 and 0.5% and for two varieties of sorghum, Savannah II and Funks BR 79, was 0.4 and 0.5% respectively.

The nutrition of Giant Cavandish banana was also examined. Using a field plot technique of his own design (continuous function), Fox sought a wide range of plant composition which can be related to banana yield. N deficiency symptoms of N were quickly recognized, and the tentative N requirement in the No. 3 fully unfurled leaf at shooting was established at 2.7%. Levels of P and K have not been strongly limiting for banana production, but low levels of S (0.12%) were detected in the plant even though S fertilizers have been used and the experiment is situated within a mile of the ocean.

Research on the relationship between sulfate adsorption, solubility and availability in highly weathered soils has been aided by 211(d) funds. Assistance has mostly been with analyses for S. The work has centered on calibrating the X-ray quantometer using plant material in which S has been determined by wet chemistry. Results of this work indicate that good sulfur nutrition of macadamia is attained when sulfate-sulfur in the soil solution is about 5 ppm and sulfur in the plant is about 0.2%.

Research and publication continued on a design for field experiments which should greatly increase the efficiency of field plots. The design is a systematic arrangement of treatments and has been called a Continuous Function Design. It should be very useful for survey investigations in underdeveloped areas.

Further, major emphasis has been placed by Fox on developing data for, and writing, "A study of highly weathered soils of Puerto Rico, Part III. Chemical Properties". This is in cooperation with the University of Puerto Rico. The completed 50 page manuscript has been approved for publication. The soils studied fall into 3 orders; 6 Oxisols, 4 Ultisols and 1 Inceptisol. There seemed to be real differences between soil orders; relative to the other soils the Oxisol differ in pH (higher), extractable aluminum (lower), and exchangeable K (higher). For other properties investigated, there was much overlap among the orders. Sulfate adsorption characteristics correspond closely with data for highly weathered soils of Hawaii developed from volcanic ash. This suggests that the reactive fraction in the Puerto Rico soils, as far as sulfate is concerned, is amorphous gel-like hydrated iron and aluminum oxides which coat mineral surfaces. Nitrification is much more sluggish than ammonification in the acid soils of Puerto Rico.

Cooperative work by Fox is also in progress with Prairie View A & M on the external P requirement of crops growing on sandy soils. Quartz sands are very important in certain areas of the tropical zone but Hawaii has no quartz sand soils. One field experiment (corn) was carried out during 1973. The results indicate that the external P requirement of the sandy soil of Prairie View is about the same as for the clay soils of Hawaii. Unfortunately for this experiment, the soil at Prairie View equilibrates at 0.1 ppm P in solution (0.01M CaCl<sub>2</sub>) which exceeds the external P requirement of 95% yield of corn.

One of the soil fertility research projects of J. A. Silva is a cooperative sugarcane experiment with the Hawaiian Sugar Planters' Association Experiment Station. A crop was harvested in the fall and a significant

response to pH was observed with two liming materials. The optimum pH for  $\text{CaCO}_3$  was 6.0 and sugarcane yields decreased at higher pH values. The optimum pH for  $\text{CaSiO}_3$  was 6.5 where yields were slightly higher than at pH 6.0 or pH 7.0. Plant samples and soil samples (to a depth of 3 feet) were collected at harvest time for analysis.

Three other studies are being conducted under the guidance of Silva. A solution culture experiment currently in progress is being used to study the effects of pH and calcium concentration on growth and nutrient uptake by sugarcane. A. El-Tahir, a graduate student, is conducting the research on sugarcane.

A comparison of plant extraction and chemical extraction of Si from soil was conducted by R. A. Khalid, a graduate student supported on 211(d) funds. Rice plants extracted larger quantities of Si from a small volume of soil than did exhaustive extraction with 0.1N acetic acid adjusted to pH 3.5 with ammonium hydroxide and containing 50 ppm P as  $\text{Ca}(\text{H}_2\text{PO}_4)_2$ . However, recovery of Si applied five years earlier was similar with the two methods. These data were incorporated in Khalid's Ph.D. dissertation entitled "Residual Effects of Calcium Silicate on the Movement and Availability of Nutrients in Tropical Soils".

The chemical reaction of calcium silicate with gibbsite are being studied by R. Alvarez, a graduate student also supported by 211(d) funds. Adsorption of calcium silicate appears to be affected by pH, concentration and accompanying ions.

In addition, the data on the lime requirement study collected by W. S. Reid of Cornell, while on sabbatical leave at the University of Hawaii, are being summarized and interpreted.

Results of several studies are reported by C. A. Bower, who is supported by the 211(d) grant. Information on the salt tolerance of crops grown under cover in the tropics and on standards for assessing soil salinity to plant growth on tropical soils is one study.

The salt tolerance of "Tropic", a principal variety of tomato grown in Hawaiian greenhouses, was determined in the plastic greenhouse at the Kona Research Station. The Honuaulu clay loam, a Hydric Dystrandept, having saturated paste, field capacity, and wilting water contents of 70, 60, and 32%, respectively, was adjusted to five levels of salinity by the addition of a 1:1 mixture of NaCl and CaCl<sub>2</sub>. The levels of salinity were such that at saturation the electrical conductivities of the soil solutions were approximately 1, 4, 8, 12, and 16 mmho/cm. Thirty-three pound weights of each batch of treated soil were placed in 5-gallon capacity pots having a drainage outlet. The water content of the potted soil, when drainage ceased (60.5%), was almost equal to the field capacity content. A single one-month old seedling was transplanted to one pot, ample nutrients were applied and each treatment was replicated four times. More or less uniform distribution of salt in the pots was maintained by partially leaching the pots periodically and returning the saline leachate to the top of the pot. Otherwise, irrigation was with salt-free water. The growth period was five months. Relations between the relative yield of marketable tomato and the electrical conductivity of the soil water at the field capacity and saturated paste water contents were determined. The absolute yield at the lowest yield of salinity was 9.1 pounds per plant. The relations at the field capacity water content showed that the Tropic variety, when compared with similar data (U.S. Salinity Lab) for temperate soils and for varieties of tomato grown in Western U.S., is only half as salt tolerant. On the other

hand, the relations at the saturation water-content erroneously indicated that the varieties have similar tolerance. The discrepancy results from the fact that with most temperate zone soils the saturation water content is about twice the field capacity rather than about the same as is the case for the Honuauolu soil. The Manu soil, also a Hydric Dystrandept, used for the greenhouse production of tomato at Volcano, Hawaii, actually has a higher field capacity water-content (98%) than saturated paste water-content (90%), apparently owing to disruption of aggregates during preparation of the paste. Additional data are needed on the relation between the saturated paste and field capacity water contents of tropical soils. If the relation is around 1:1 rather than 1:2, then most published data relating the electrical conductivity of saturation extracts to crop yield reductions should be divided by two.

With the marked increase in the commercial growing of tomato under plastic cover in the tropics, information is needed on irrigation practices and amounts of irrigation water required. In cooperation with B. A. Kratky of the Hawaii Agricultural Experiment Station Horticulture Department, Bowers initiated a split-plot irrigation experiment with the Tropic variety of tomato in the Kona Research Station plastic greenhouse. The experimental variables are two methods of irrigation, drip and 18-inch wide basins (main plots), and three levels of water achieved by irrigating when the soil-water tension 6 inches to the side of the plant at the depth of 6 inches reached 200, 400, and 600 cm of water (subplots). For all treatments, two quarts of water per plant are applied at each irrigation and a record of the amounts of water applied is maintained. Presently, 45 days after initiation of the experiment, the superiority of drip irrigation at the 400 and 600 cm-water

tension treatments is evident but larger amounts of water are required to maintain a given soil-water tension with drip irrigation.

Response of macadamia seedlings to liming is also being studied by Bower in soils which are as acid as pH 4.0 at the Kona Research Station. Crushed coral limestone was applied to small plots at rates of 0, 2 1/2, and 5 tons per acre; the lime was incorporated to a depth of 6 inches by rototilling, and young ungrafted seedlings about 12 inches in height were transplanted. The treatments were triplicated. Eight months after treatment, no visual response is evident.

Development of quantitative methods of assessing the tendency of K to leach from various tropical soils is still another study of Bower. This study includes predicting leaching losses as a function of depth of water moving through the soil. Equations have been developed for two volcanic ash soils.

3.3 Travel: Several faculty travels were supported by the 211(d) grant to fulfill some of the objectives of the project, to coordinate project activities, or to provide the faculty in developing further competence in carrying out the objectives of the project.

A summary of the travel activities are:

L. D. Swindale attended two joint meetings of the 211(d) Council of Deans and the Executive Committee and one separate meeting of the Council of Deans in Washington, D.C. during 1973-74. These meetings considered current progress and the future of the Consortium. The Council has paid particular attention to developing policies and recommendations to the Executive Committee that will ensure the continuation of the Consortium, strengthen it and enable it to provide greater service to AID in the future.

W. G. Sanford also attended the annual meeting of the 211(d) Council of Deans and the Executive Committee in November, 1973. Then, he presented a paper "Effect of Temperature on the Uptake of Nutrients by Pineapple Roots" at the annual meeting of the American Society of Agronomy in Las Vegas, Nevada (November, 1973).

R. C. Jones and G. W. Gribble attended the annual meeting of the American Society of Agronomy at Las Vegas, Nevada (November 11-16, 1973). Two papers were presented: "Plant Tissue Analysis by X-ray Fluorescence Quantometry" by R. C. Jones and E. N. Okazaki and "Total Elemental Analysis of Rocks and Soils by X-Ray Fluorescence Quantometry" by G. W. Gribble, R. C. Jones, G. Uehara, and E. N. Okazaki.

J. A. Silva presented a paper at the annual meeting of the American Society of Agronomy in Las Vegas, Nevada (November, 1973). The paper entitled "Fate of Applied Silicon in an Oxisol during Five Years Cropping" was authored by R. A. Khalid, J. A. Silva, and R. L. Fox.

J. A. Silva also spent a week in Puerto Rico (March, 1974) working with F. H. Beinroth of University of Puerto Rico to formulate plans for the Workshop on Experimental Design which was held in Hawaii during May 20-24, 1974. Plans for coordinating the AID project on the "Technology Transfer" were also made with the staff of the University of Puerto Rico. Some soils and crops of Puerto Rico were observed during the visit.

D. P. Bartholomew traveled to Raleigh, North Carolina, where he is on a half-year sabbatical leave at North Carolina State University (starting December, 1973).

W. T. Harada attended a course in project evaluation which was presented by the AID in Washington, D. C. (December, 1973).

H. Ikawa traveled September 29-October 6, 1973 to participate in Park City, Utah, in an AID-sponsored symposium, "On-Farm Management Research and Implementation" and to present a paper entitled "Systems of Soil Classification and their Relation to Water Management" by L. D. Swindale, G. Y. Tsuji, and H. Ikawa.

H. Ikawa also participated in the Western Regional Technical Work Planning Conference of the National Cooperative Soil Survey (Soil Conservation Service, USDA) held in San Diego, California during January 21-25, 1974. Benefit of this conference is to be informed of the latest developments in the soil survey program which includes soil characterization, classification, and interpretation at the University.

H. Ikawa attended a seminar on "Soil Management and the Development Process in Tropical America" in Cali, Colombia (February 10-14, 1974) and also participated in a post seminar soils tour of Colombia, Peru, and Brazil (February 15-25, 1974). Contacts with individuals from different countries, universities, and research institutes were most beneficial. Information gained and compiled during the seminar and the soils tour (including numerous photographs) are also very beneficial for use in research and teaching by the individual and others in the Department.

S. A. El-Swaify, while on a sabbatical leave in Australia, traveled from Adelaide to Perth during October 22-November 3, 1973 to meet with the scientists at CSIRO and at University of Western Australia. Conferences were held in the subject areas of soil structure, mineralogy, conservation, and properties and roles of sesquioxides. He also traveled to Brisbane and Townsville during December 1-13, 1973 to consult with and discuss research programs of colleagues at CSIRO in Queensland, at the Universities of Queensland, Griffith, and James Cook, and at the Sugar Bureau. Information gained on these trips will benefit the research program of the individual as well as that of the Department.

R. L. Fox was given partial support to attend the following meetings:

(a) Colorado State University - Prairie View A&M College - Texas A&M.

Attended the Western Regional P Work group meetings and presented a report "Relationships between yields and the external and internal phosphorus requirements of crops"; presented a seminar on problems associated with growing crops on highly weathered soils at Texas A&M and gave guest lectures at Prairie View.

(b) University of W. I., Trinidad - Windward Islands - Dominican Republic.

Presented papers "Examples of Anion and Cation Adsorption by soils of Tropical America" and participated in field trips to several of the Windward Islands.

(c) Nevada - Florida. Presented paper on "Internal and external P

requirements for corn and sorghum growing on highly weathered soils" before the Soil Science Society of America and presented an invited paper on "Management of Andepts" before the Florida Soils and Crops Society and participated in seminars before the Department of Soils, University of Florida.

#### 3.4 Reports, Working Papers, and Publications

Balasubramanian, V., Y. Kanehiro, P. S. C. Rao and R. E. Green. 1973. Field study of solute movement in a highly aggregated oxisol with intermittent flooding: 1. Nitrate. Jour. of Environ. Qual. 2(3):359-362.

Balasubramanian, V. and Y. Kanehiro. 1974. Adaptability of nitrate specific ion electrode for nitrate analysis in tropical soils. Hawaii Agr. Exp. Sta. Dept. Paper 19. 16 pp.

Beinroth, F. H., G. Uehara, and H. Ikawa. 1974. Geomorphic relationships of Oxisols and Ultisols on Kauai, Hawaii. Soil Sci. Soc. Amer. Proc. 38:128-131.

Beinroth, F. H., H. Ikawa, and G. Uehara. 1974. Classification of the soil series of the State of Hawaii in different systems. AID Bulletin (manuscript submitted).

- Fox, R. L. 1973. Fertility of the savanna soils. Seminario Sobre Suelos de Sabana en el Tropico. Dominican Republic.
- Fox, R. L. 1973. Phosphorus of Oxisols. Proceedings Colombia Soil Sci. Soc. (in press).
- Fox, R. L. 1973. Management of Andepts. Soil and Crop Sci. Soc. Florida Proc. (in press).
- Fox, R. L. 1973. Agronomic investigations using continuous function experimental designs--Nitrogen fertilization of sweet corn. Agron. Jour. 65:454-456.
- Fox, R. L. 1974. Examples of anion and certain adsorption by soils of Tropical America. Tropical Agric. (Trinidad). In press.
- Fox, R. L. and B. Isobe. 1973. Crop quality control through soil management techniques: manipulating nitrogen and water to ripen sugarcane. Illustrated Concepts in Tropical Agriculture No. 5.
- Fox, R. L. A study of highly weathered soils of Puerto Rico. Part III. Chemical properties. Neoderma (Manuscript submitted).
- Goswami, K. P. and R. E. Green. 1973. Simultaneous extraction of hydroxy-atrazine, atrazine, and ametryne from some Hawaiian soils. Soil Sci. Soc. Amer. Proc. 37:702-706.
- Jones, R. C., and G. Uehara. 1973. Amorphous coatings on mineral surfaces. Soil Sci. Soc. Amer. Proc. 37:792-798.
- Kagbo, R. B., R. S. de la Pena, D. L. Plucknett, and R. L. Fox. 1974. Mineral nutrition of taro (*Colocasia esculenta*) with special reference to phosphorus. Third Intern. Symposium, Tropical Root Crops, Sierra Leone.
- Keng, J. C. and G. Uehara. 1974. Chemistry, mineralogy, and taxonomy of oxisols and ultisols. Submitted to Proc. of Florida Soil and Crop Science Society.
- Rajan, S.S.S. and R. L. Fox. 1974. Phosphate adsorption by some Indian soils and its application for predicting phosphate requirements of millet. Indian Journal of Soil Science (Manuscript submitted).
- Rajan, S.S.S. and R. L. Fox. Phosphate adsorption by soils II. Interpretation of adsorption isotherms and influence of phosphate adsorption on release of hydroxyl, sulfate and silicate. (Manuscript being reviewed).
- Rao, P.S.C., R. E. Green, V. Balasubramanian, and Y. Kanehiro. 1974. Field study of solute movement in a highly aggregated Oxisol with intermittent flooding: 2. Picloram. J. Environ. Quality 3(3). (In press).

- Ravoof, A. A., R. L. Fox, and W. G. Sanford. 1973. Low soil temperatures depress root activity in the tropics. Illustrated Concepts in Tropical Agriculture No. 6.
- Santo, L. T. and G. Y. Tsuji. 1974. Soil bulk density and water content measurements by gamma-ray attenuation techniques. Accepted as Tech. Bull. Hawaii Agr. Exp. Sta. No. 98.
- Swindale, L. D., G. Y. Tsuji, and H. Ikawa. 1973. Systems of soil classification and their relation to water management. Symposium on "AID's Role in On-Farm Management Research and Implementation." Park City, Utah. 10 pp.
- Tsuji, G. Y., R. T. Watanabe and W. S. Sakai. 1974. Influence of soil micro-structure on water characteristics of selected Hawaiian soils. Submitted to Soil Sci. Soc. Amer. Proc.
- Uehara, G. and J. C. Keng. 1974. Management implications of soil mineralogy in Latin America. Symposium on "Management of Tropical Soils." Cali, Colombia.
- Uehara, G., M. S. Nishina, and G. Y. Tsuji. 1974. The composition of Mekong river silt and its possible role as a source of plant nutrient in Delta soils. Report submitted to the United Nations Committee for Coordination of Investigations of the Lower Mekong Basin, Bangkok, Thailand.
- Warner, R. M., R. L. Fox and S. Prasomsook. 1974. Preliminary report on banana nutrition research. Hawaii Farm Science (in press).
- ### 3.5 Theses and Dissertations
- Balasubramanian, V. 1974. Adsorption, denitrification, and movement of applied ammonium and nitrate in Hawaiian soils. Ph.D. dissertation. Univ. of Hawaii.
- Gribble, G. W. 1974. Total chemical analysis of rocks, soils, and clay minerals by x-ray fluorescence spectrometer. M.S. thesis. Univ. of Hawaii.
- Hirunburana, N. 1974. Inorganic nutrition of papaya (*Carica papaya* L.) and macadamia (*Macadamia integrifolia*, F. Muell). Ph.D. dissertation. Univ. of Hawaii.
- Keng, J. C. W. 1974. Surface chemistry of some constant potential soil colloids. M.S. thesis. Univ. of Hawaii.
- Khalid, R. A. 1974. Residual effects of calcium silicate on the movement and unavailability of nutrients in tropical soils. Ph.D. dissertation. Univ. of Hawaii.
- Nishina, M. S. 1974. The composition of Mekong River silt and its possible role as a source of plant nutrient in the Delta. M.S. thesis. Univ. of Hawaii.
- Santo, L. T. 1974. Soil water hysteresis in the inter-aggregate voids of two Hawaiian Oxisols. M.S. thesis. Univ. of Hawaii.

### 3.6 Dissertation Abstracts

Balasubramanian, V. 1974. Adsorption, denitrification, and movement of applied ammonium and nitrate in Hawaiian soils.

Ph.D. dissertation. Univ. of Hawaii

The factors influencing adsorption, denitrification, and movement of applied ammonium and nitrate in tropical Hawaiian soils were investigated. Suggestions are incorporated to maximize crop utilization of field-applied fertilizer nitrogen and to minimize loss of mineral nitrogen through leaching and denitrification.

Some oxidic tropical soils, such as the Hydrandepts and Gibbsihumox, in Hawaii were found to adsorb nitrate significantly in pH ranges below 6. Non-specific anion adsorption is believed to be the major mechanism by which nitrate was adsorbed.

The zero point of change (ZPC), which has a close relation with non-specific anion adsorption, is defined as the pH where the net sum of change is zero. The high ZPC of the subsoil of the Hydrandepts was attributed to the extensive hydration of their iron and aluminum oxides. Hydrolysis and polymerization of the hydrated oxides were suggested as major mechanisms for the decrease of ZPC and pH on drying the Hydrandepts.

Any change in the ZPC was shown to vary the nitrate adsorption. The significant decrease of nitrate adsorption due to dehydration of the Hydrandepts was explained by the change in the ZPC, pH, crystallinity, and surface area on drying. Since this dehydration process is irreversible, it was concluded that these soils should not be allowed to dry excessively by exposure to direct sun and wind as to preserve their high exchange capacities, both for anions and cations.

The surface of the Hydrandepts and Gibbsihumox became less positive or more negative on liming, and this was reflected in the (increased) ammonium and (decreased) nitrate adsorption by the limed soils. The finding that raising of soil pH beyond 5.5 with liming produced  $\text{NO}_3^-$  repulsion in these soils should be taken into consideration in any liming program.

Denitrification loss was found to be important only in soils with large amounts of water-soluble organic matter and nutrients. Available energy source appeared to play a dominant role in denitrification.  $\text{N}_2$  and  $\text{N}_2\text{O}$  gases were the prime denitrification products in all the soils studied. Denitrification potential was very low in Oxisols with poor organic carbon (both water-soluble and total) content.

In an infiltration study, it was found that the practically irreversible adsorption of ammonium was responsible for its retention in the Molokai soil. It was further shown that the higher the amount of water infiltrated, the deeper was the position of nitrate peak. An explanation is given on how to take advantage of the lag of nitrate peak with respect to the wetting front in the initially moist soil during transient water flow. For soils with the same initial moisture content, the depth of nitrate peak was in direct proportion to its wetting front. Thus by controlling the wetting front, one can control the depth of maximum solute concentration, irrespective of the rate of water application.

In short, modified management practices based on the knowledge of nitrogen transformation and transport in soils as well as nitrogen uptake by crops will ensure efficient (nitrogen) fertilizer use in crop production with a minimum chance for the pollution of ground water by nitrate.

Hirunburana, N. 1974. Inorganic nutrition of papaya (*Carica papaya* L.) and macadamia (*Macadamia integrifolia*, F. Muell). Ph.D. dissertation. Univ. of Hawaii.

Nutritional requirement study of papaya and macadamia were conducted in three parts: (i) visual deficiency symptoms for N, Mg and B and the internal concentrations of these three elements associated with the symptoms in the greenhouse experiment were established; (ii) the effects of calcium carbonate and calcium sulfate with various sources of N on the nutrient composition and growth of papaya were investigated in the field experiment; (iii) the role of B in reducing Mn toxicity of papaya on the Wahiawa soil in this field was studied.

Papaya trunk weight, as well as trunk circumference, was found to be usable as an index for final yield of papaya. Maximum trunk weight was obtained at the 120 ppm N in the substrate with 1.73 percent N content in petiole No. 6. Concentrations of N in excess of 120 ppm resulted in decreases of Mg, S, K, Fe, and Mn, and increased concentrations of P, Ca and Zn.

The external Mg requirement for optimum growth of papaya was about 12 ppm. At this level, Mg content of papaya was found to be 0.22 percent in the leaf blade and 0.61 percent in the petiole. The increase in Mg concentrations in the substrate did not affect the internal concentrations of P and K but caused Ca, Fe, Mn and Zn concentrations to decrease.

Under greenhouse conditions, maximum growth of macadamia was obtained at the 30 ppm N in the substrate which was associated with 1.6 percent N in recently matured leaves. The excess N applications injured macadamia roots. The content of P, Ca, Mn, Zn and probably Fe in leaf decreased when N was increased beyond 120 ppm.

Visual symptoms of Mg deficiency in macadamia appeared at 0 to 1.5 ppm Mg in the added solution. The critical level of Mg in macadamia tree was established as 0.12 percent Mg in recently matured leaves. There was no pronounced effect of Mg on other nutrient composition of macadamia with the exception of K decrease.

Recently matured leaf blades seemed to be the best plant part to be used as an indicator of B status in papaya. Boron deficiency symptoms were associated with B content in leaf blades below 12 ppm whereas B toxicity occurred at 0.4 ppm added B. It was recommended to keep the internal B content at the range of 30 to 50 ppm B.

The critical B content of macadamia was 10 ppm in recently matured leaves. A 20 ppm B content in leaves was recommended as the sufficiency level. The concentrations of B above 65 ppm in recently matured leaves were probably in the range of toxicity.

The effect of calcium carbonate and calcium sulfate with various sources of N on growth and nutrient composition of papaya was investigated in the Wahiawa soil. Applications of Ca in either forms at the rates of 400, 800 and 1200 ppm resulted in highly significant dry weight increase over the control. Reduction of growth caused by overliming was shown at the level of 1200 ppm Ca as calcium carbonate. Therefore, the optimum level of liming the soil to improve papaya growth should be to the pH range of 5.7 to 6.1 or 5.5 to 6.5 me/100g of Ca.

The application of calcium carbonate and calcium sulfate alleviated Mn toxicity in Wahiawa soil. The preplanting  $N$   $NH_4OAc$  extractable soil Mn at 7.2 ppm was considered enough to cause injury to papaya growth. The tolerable content of Mn for papaya growth was below 140 ppm in leaf blades and 35 ppm in pestioles.

The amount of Ca in the soil as well as soil pH were used to approximately estimate a toxic concentration of Mn in papaya by using a multiple regression analysis. A more precise estimation was obtained when soil Mn and soil Mg were also included as variables in the analysis.

Calcium sulfate applications increased the concentrations of leaf N, P, K and S. A similar trend was found in calcium carbonate experiment except leaf N and P decreased at the highest level of Ca application (1200 ppm). Urea application significantly increased soil pH in both calcium carbonate and calcium sulfate plots, and lowered extractable Mn than did ammonium nitrate and ammonium sulfate.

The effect of B application on alleviation of Mn toxicity was demonstrated in Wahiawa soil using papaya as the indicator plant. Application of B to the soil tended to decrease Mn content of leaf blades at postplanting, especially at the levels of 0.2 and 0.4 ppm adjusted B levels in soil solution. Below or above these concentrations, the influence of B seemed to be less effective. It can be concluded that the effect of B on papaya growth in high Mn soil of Wahiawa is an indirect one. Possibly, B can react in the following ways: (i) forming complex molecules with soil Mn directly as it does with the hydroxides of Al and Fe; (ii) depressing amounts of Mn absorbed by plant roots, and (iii) increasing availabilities of other elements, such as Ca, Mg, P and Fe, which in turn may enable papaya plants to survive the high Mn content in the soil.

Khalid, R. A. 1974. Residual effects of calcium silicate on the movement and unavailability of nutrients in tropical soils. Ph.D. dissertation. Univ. of Hawaii.

The residual effects of calcium silicate on plant uptake and movement of nutrients in a Gibbsumox were studied in a series of three experiments. First, Kikuyu grass and desmodium were grown in the field to determine the magnitude of response to residual Si applied several years earlier at various P and pH levels; second, the partial recovery of applied Si during five years of cropping was determined at 3 pH levels; and third, uptake of residual Si by rice grown on soil collected from the field experiment at the end of five years was studied in a growth chamber. A study of soil Al extraction methods in relation to plant Al uptake and yield was also conducted on some Hawaiian soils.

The combined yields of seven harvests of kikuyu grass and desmodium increased significantly with increasing residual P levels, but was not significantly affected by residual Si or soil pH. The relative yield differential between the three Si treatments decreased sharply with time and at the end of 56 months yield from 1660 Si was only 2.5% higher than that without Si, whereas yield from 830 Si was less than the yield without Si. The decline with time in relative yield response to P applications, on the other hand, was small indicating a continued efficiency of P applied 56 months earlier in increasing yields on a Gibbsumox. However, it should be pointed out that two supplemental additions of P were made 21 and 27 months after the initial treatments. Although residual Si produced highly significant increases in water-extractable soil Si, the levels at the end of the experiment were low which suggests that supplemental amounts of calcium silicate may be required to maintain yield response to Si. Modified Truog-extractable P was significantly higher at 1660 Si than at zero Si five years after Si applications. Phosphorous requirements of a Gibbsumox were decreased significantly by residual Si and P in samples collected after 5 years of cropping. However, residual P was

about 7 times more effective than residual Si in reducing P requirements. Multiple regression analysis indicated that in addition to the initially applied treatments, soil P and Al and plant P, K, Mg and possibly also Mn, Zn, Al and Ca were important to plant growth in both species.

Plant uptake by the sugarcane plant and ratoon crops, corn, and seven harvests of kikuyu grass accounted for 12 to 21 percent of the applied Si while exhaustive extraction of profile samples taken at the end of five years with 0.1N acetic acid, adjusted to pH 3.5 and containing 50 ppm P, recovered 14 to 28 percent of the applied Si. There was no evidence that applied Si moved below 30 cm. Total recovery of applied Si ranged from 28 to 43 percent which means that 57 to 72 percent of the applied Si remained in the soil in some form not readily displaced by phosphate solution.

Rice plants extracted proportionately more native Si than did phosphate solution which resulted in comparable amounts of added Si being recovered by the two methods. Silicon uptake by rice accounted for 8 to 30 percent of applied Si and exhaustive phosphate extraction recovered 13 to 23 percent of applied Si.

The amount of Al extracted by various solutions decreased in the order of 1N ammonium acetate + 0.2N barium chloride, pH 4.8 > 1N barium chloride  $\geq$  1N potassium chloride  $\geq$  water  $\geq$  0.01M calcium chloride. Aluminum extracted from five soils was in the order: Akaka (Typic Hydrandept) > Hali (Typic Gibbsiumox) > Wahiawa (Tropeptic Eustrtox) > Lualualei (Typic Chromustert) = Kawaihai (Ustollic Camborthid) which was related to the degree of weathering and the amount of rainfall affecting the soil. Soil Al extracted with unbuffered solution, especially 1N potassium chloride, was more closely related to plant Al whereas Al extracted with buffered solutions, especially 1N ammonium acetate, pH 4.8, was more closely related to plant yield than

that extracted with other methods. However, R values for the soil Al-yield relationships were generally lower than those for soil Al-plant Al relationships suggesting that while soil Al has a strong influence on plant Al, it has considerably less effect on yield.

4. Impact of Grant Supported Activities in Developing Institutional Capabilities: Through the 211(d) grant, the University of Hawaii has been able to improve the teaching and research capabilities. In undergraduate teaching, continuous efforts were made to up-grade the courses by further improvement in the audio visual tutorial approach and by publication and distribution of illustrated concepts. In graduate teaching, the students and staff were given the opportunity to attend the soil formation and classification class which was offered by a visiting professor. There were also opportunities to attend several seminars presented by visiting Professors Southard, Munns and Doxtader who were supported by the grant. Through travel and participation in seminars or like activities in out-of-state institutions, the teaching faculty developed further competency by contact with other of similar interests and by collecting teaching aids or materials.

In research, special effort was made to strengthen the programs of soil mineralogy. Instrumental methods of analysis have been or are being developed, and these developments have directed influence on the other research programs in the Department; for example, mineral composition of soils and the relation to plant nutrition. Input also has been made in the areas of soil chemistry, soil physics, and soil characterization and classification. The studies of these areas are significant because they have direct bearing on the knowledge of the behavior of soils. Then by conducting research in soil fertility and crop production, further understanding of the management of tropical soils was obtained. In this fourth year of the grant, the University of Hawaii,

together with the other members of the consortium are beginning to show the capability to undertake projects which deal with less developed countries. Hawaii and Puerto Rico, for example, are planning to carry out a Benchmark Soils Project which will investigate crop production and land capabilities of a network of tropical soils in Hawaii, Puerto Rico, Africa, Asia, and South America.

5. Utilization of Institutional Resources in Development: The following activities were performed by L. D. Swindale, Associate Director of the Hawaii Agricultural Experiment Station:

(a) Development of an AID contract with the University of Hawaii on "Crop Production and Land Capabilities of a Network of Tropical Soil Families"

(b) Organizing and participating in a workshop on "Experimental Designs for Predicting Crop Productivity with Environmental and Economic Inputs" which was jointly sponsored by AID, the University of Puerto Rico, and the University of Hawaii, and involved all the Consortium Soils Departments.

(c) Developed an agreement with ARS for establishment in the University of Hawaii of on-line bibliographic and current research awareness services for tropical agricultural research.

(d) Worked towards the establishment of a Tropical Agricultural Research and Training Center at the University of Hawaii under the authority of section 406 of the Ford for Peace Act (PL - 480).

G. Uehara is on a year's sabbatical leave (September 1973 - August 1974). He was at Cornell University until December 1973, working with M. Drosdoff and M. G. Cline; and is now at North Carolina State University working with C. B. McCants and others. At both institutions, he held seminars and classes on the physics, chemistry, and mineralogy of tropical soils. During the year, he presented papers at the Florida Soil and Crop Science Society and

at a seminar on "Soil Management and the Development Process in Tropical America" in Cali, Colombia (February 10-14, 1974). He also participated in a post seminar soils tour of Colombia, Peru, and Brazil (February 15-25, 1974)

D. P. Bartholomew is on a half-year's sabbatical leave at North Carolina State University. He has taken four soils from Hawaii, two Oxisols and two Ultisols, for study in the phytotron at North Carolina State.

J. A. Silva coordinated the program for the workshop in Hawaii on "Experimental Designs for Predicting Crop Productivity with Environmental and Economic Inputs" (May 20-24, 1974). He also presented a position paper of Hawaii "Field Experimentation to allow Economic Evaluation of Management and Environment Effects on Soil Productivity. Silva was assisted by G. Y. Tsuji, H. Ikawa, and others in carrying out the program of the workshop. The results of the workshop can be used to guide a new AID-sponsored project on correlating food crop yields on a network of benchmark soils and in determining scientifically the transferability of agroproduction technology among developing tropical countries.

Following are students and faculty or staff in the Department of Agronomy and Soil Science at the University of Hawaii: Graduate Students [support from State, East-West Center (U.S. State Department), Rockefeller and Ford Foundations, Country of Origin, FAO, etc.]

<u>Name</u>	<u>Arrival Date</u>	<u>Advisor</u>	<u>Home Country</u>
<u>Agronomy--M.S.</u>			
1. Aragon, Ernesto L.	Fall '72	D. L. Plucknett	Philippines
2. Ayers, Dennis W.	Fall '71	H. Y. Young	U.S.
3. Hurdus, Alan R.	Fall '71	P. P. Rotar	U.S.
4. Ingamells, James L.	Fall '74	P. P. Rotar	U.S.
5. Kadzimin, Saleh B.	Fall '73	P. P. Rotar	Malaysia
6. Kagbo, Robert	Fall '72	W. G. Sanford	Sierra Leone

Agronomy--Ph.D.

1. El-Tahir, Awad	Spring '70	J. A. Silva	Sudan
2. Eriksen, Flemming I.	Spring '74	A. S. Whitney	Denmark
3. Floresca, Emmanuel	Fall '71	D. L. Plucknett	Philippines
4. Guevarra, Anacleto	Fall '71	P. P. Rotar	Philippines
5. Pellek, Richard	Fall '71	Y. N. Tamimi	U.S.
6. Pyon, Jong Yeong	Fall '72	D. L. Plucknett	Korea
7. Seng, Tee	Spring '68	W. G. Sanford	Malaysia
8. Skolmen, Roger G.	Fall '73	P. P. Rotar	U.S.
9. Walters, Gerald A.	Fall '73	P. P. Rotar	U.S.

Soil Science--M.S.

1. Daud, Abdul R. S.	Fall '72	S. A. El-Swaify	Malaysia
2. Elder, Vincent	Spring '73	B. L. Koch	U.S.
3. Furukawa, Michael N.	Spring '73	R. E. Green	U.S.
4. Oya, Jean	Fall '72	B. L. Koch	U.S.
5. Tama, Kato	Fall '72	S. A. El-Swaify	Cook Is.
6. Tengah, Abdullah B. C	Fall '72	S. A. El-Swaify	Malaysia

Soil Science--Ph.D.

1. Alvarez, Robustino	Fall '72	J. A. Silva	Argentinian
2. Asghar, Mohammad	Fall '72	Y. Kanehiro	Pakistan
3. Arain, Mohammad Saeed	Fall '71	R. L. Fox	Pakistan
4. Braide, Jonathan	Fall '68	G. Uehara	Nigeria
5. Hudnall, Wayne H.	Spring '72	R. C. Jones	U.S.
6. Jellinger, Alice	Spring '69	P. C. Ekern	U.S.
7. Mukhtar, Muhammad	Fall '72	R. E. Green	Pakistan
8. Periaswamy, Sirapalli	Fall '70	H. Ikawa	India
9. Qureshi, Ara H.	Fall '73	Y. N. Tamimi	Pakistan
10. Rao, Palakurthi	Spring '70	R. E. Green	India
11. Stoop Willem	Fall '71	R. L. Fox	Netherlands
12. Syed, Muhammad M.	Fall '69	S. A. El-Swaify	India
13. Wann, Shing-Sun	Fall '73	G. Uehara	Republic of China
14. Watanabe, Roger T.	Fall '69	G. Uehara	U.S.

Research and Teaching Staff (Support from State funds)NameSpecialtyAgronomy

- |                          |                                       |
|--------------------------|---------------------------------------|
| 1. Bartholomew, Duane P. | Crop Physiology, Plant Nutrition      |
| 2. Bullock, Richard      | Tree Physiology                       |
| 3. De La Pena, Ramon     | Root Crop Production, Crop Physiology |
| 4. Plucknett, Donald L.  | Crop Management, Weed Control         |
| 5. Rotar, Peter P.       | Plant Breeding, Cytogenetics          |
| 6. Sanford, Wallace G.   | Plant Nutrition, Physiology           |
| 7. Tamimi, Yusuf N.      | Forest Soils, Nutrition               |
| 8. Thompson, John R.     | Crop Production                       |
| 9. Urata, Ukio           | Plant Breeding                        |
| 10. Whitney, A. Sheldon  | Plant Nutrition, Crop Physiology      |
| 11. Young, Hong Yip      | Plant Nutrition, Chemistry            |
| 12. Matsuyama, Dennis    | Research Associate                    |
| 13. Yoder, Ronald        | Research Associate                    |

Soil Scienc

- |                         |  |
|-------------------------|--|
| 1. Ekern, Paul C. Jr.   | Soil Management, Soil Physics            |
| 2. El-Swaify, Samir A.  | Soil Physics, Irrigation                 |
| 3. Fox, Robert L.       | Soil Fertility, Crop Management          |
| 4. Green, Richard E.    | Soil Physics and Soil-Pesticide Behavior |
| 5. Ikawa, Haruyoshi     | Soil Genesis and Classification          |
| 6. Jones, Rollin C.     | Soil Mineralogy                          |
| 7. Kanehiro, Yoshinori  | Soil Chemistry, Soil Fertility           |
| 8. Koch, Burton         | Soil Microbiology                        |
| 9. McCall, Wade. W.     | Soil Fertility                           |
| 10. Silva, James A.     | Soil Fertility, Soil Chemistry           |
| 11. Swindale, Leslie D. | Soil Genesis and Classification          |
| 12. Uehara, Goro        | Soil Physics, Mineralogy, Water Science  |
| 13. Watanabe, Roger T.  | Soil Testing                             |

Research Staff (Contractual)NameTitle

- |                       |                          |
|-----------------------|--------------------------|
| 1. Ahuja, Lajpat      | Assistant Soil Scientist |
| 2. Ayers, Dennis      | Research Associate       |
| 3. Bower, Charles     | Soil Scientist           |
| 4. Chang, Annie       | Junior Researcher        |
| 5. Dangler, Edgar     | Assistant Soil Scientist |
| 6. Escalada, Rudolpho | Junior Agronomist        |
| 7. Mapes, Marion      | Assistant Agronomist     |
| 8. Mishima, Helen     | Research Associate       |
| 9. Okazaki, Ernest N. | Junior Soil Scientist    |
| 10. Tsuji, Gordon Y.  | Assistant Soil Scientist |

## Staff and Students (Full or Partial Support from 211(d) Grant during 1973-74)

<u>Position</u>	<u>Name</u>	<u>Specialty</u>
Graduate Research Assistant	Robustiano Alvarez	Soil Fertility
Soil Scientist	Charles Bower	Soil Chemistry
Graduate Research Assistant	Jonathan Braide	Soil Chemistry & Mineralogy
Jr. Researcher	Annie Chang	Analytical Chemistry
Visiting Associate Professor	Kenneth Doxtader	Soil Microbiology
Graduate Research Assistant	Vincent Elder	Herbicide Decomposition
Graduate Research Assistant	Ericksen Flemming	Pasture Management
Graduate Research Assistant	Michael Furukawa	Soil Physics
Graduate Research Assistant	Grant Gribble	Soil Mineralogy
Graduate Research Assistant	Niwat Hirunburana	Soil Fertility
Graduate Research Assistant	Wayne Hudnall	Soil Mineralogy
Graduate Research Assistant	Alice Jellinger	Soil Physics
Graduate Research Assistant	Rashid Khalid	Soil Fertility
Visiting Soil Scientist	Donald Munns	Soil Fertility
Jr. Soil Scientist	Ernest Okazaki	Soil Chemistry & Mineralogy
Graduate Research Assistant	Jean Oya	Soil Microbiology
Graduate Research Assistant	Richard Pellek	Forest Soils
Graduate Research Assistant	S. P. Periaswamy	Soil Genesis
Assistant Soil Scientist	William Sakai	Electron Microscopy
Graduate Research Assistant	Lance Santo	Soil Physics
Visiting Soil Scientist	Alvin Southard	Soil Genesis
Assistant Soil Scientist	Gordon Tsuji	Soil Physics
Graduate Research Assistant	Shing-Sun Wann	Soil Physics

6. Other Resources for Grant-Related Activities: Approximately 15 members of the staff who are supported by state or federal funds are directly and indirectly related to the research activities of the 211(d) grant. Many of them serve as academic advisors to graduate students who are supported by the 211(d) grant. The state or federal-supported salaries exceed \$200,000 annually.

The study of the Lower Mekong Basin by G. Uehara, principal investigator, reported in the previous year's report, has provided \$40,000 to the Department.

The recent grant from AID for the benchmark soil project to study crop production and land capabilities of a network of tropical soil families will provide still another \$680,630 within a period of two years.

## 7. Next Year's Plan of Work:

7.1 Teaching and Extension Services: A Tropical Agronomy Short Course will be held in Honolulu in June, 1975. The program of this short course will be planned and coordinated by W. G. Sanford, G. Uehara, and W. W. McCall.

At least two of the staff members may participate in the ICRISAT meeting which will be held in December, 1974.

Plans are being made to organize a file of reports and other materials obtained at various seminars or symposia attended by the various members of the Department. The file will also include colored slides with notes or narration. These materials can then be available to other members of the Department for use in their teaching and extension activities.

7.2 Research: The mineralogical and chemical research programs of R. C. Jones, E. N. Okazaki, W. H. Hudnall, J. Braide, and others will continue with further work by means of the x-ray quantometer, electron microscope, and the x-ray diffractometer. As cited under the Accomplishment section, efforts will be directed toward improvement in the total analysis of rock, soil, and mineral samples, especially in the high concentrations of  $Fe_2O_3$  and the low concentration of  $SiO_2$ .

The mineralogical investigation of two sequences of volcanic ash soils will be initiated by W. H. Hudnall. Aside from detailed studies by transmission and scanning electron microscopy, techniques such as neutron activation analysis will be used to differentiate the soils formed from andesitic ash and basaltic ash. Special emphasis will also be placed on identification of amorphous inorganic materials.

The ion exchange resin study will be continued by J. Braide. Accomplishment of the objectives will facilitate analysis of many soil

samples which are being characterized for soil classification, nutrition or fertility, and crop production.

The distribution of the Alfisols or soils with high base status will be examined on the other islands of Hawaii by A. R. Southard and H. Ikawa. The geographical areas of investigation will be similar to that of Oahu; that is, on the northern slopes which are exposed to the Northeast trade-winds, in areas where there is influence of sea spray, or in areas where the parent rock or parent material are alkaline. Several pedons will be collected for laboratory characterization. Southard and Ikawa will also seek soils in Hawaii which would be similar in classification to those of Puerto Rico.

The laboratory characterization of the Humults on the island of Oahu will be made by S. P. Pariaswamy, with special emphasis on the mineralogical and physical properties and their relation to behavior. When the study is completed, it is expected that soil data interpretations can be used more effectively in supporting, for example, (1) construction of houses and other dwellings, (2) erosion control, (3) crop production, and in evaluating (4) watershed behavior and areas subject to soil shippage in Windward Oahu.

Research work on soil water hysteresis and vertical infiltration in the Molokai and Wahiawa (Oxisols) soils will be published by G. Y. Tsuji. The new Benchmark soils project, recently funded by AID, will also be coordinated by Tsuji. Sample sites must be selected; samples must be collected, characterized, and classified; and fertility experiments must finally be established to fulfill the objectives of the new project.

Further studies on nitrate accumulation in tropical plants and soils, on the movement of applied ammonium and nitrate, and on the decomposition of organic matter residue are planned by Y. Kanehiro.

The experiment of J. A. Silva and his graduate student on the pH requirements of crops will be planted to sorghum, following the harvest of the ratoon crop of sugarcane. The nutrient culture solution will be completed and the data from the sugarcane experiment will be used in preparing a Ph.D. dissertation. Work on the reaction of  $\text{Si}$  will also be continued and new instrumental procedures will be used to analyze the samples.

On sabbatical leave from the University of Hawaii will be R. L. Fox, who will be conducting soil fertility experiments at IBADAN in Nigeria.

Joining the staff at the University of Hawaii on a six-month sabbatical leave from New Mexico State University will be J. U. Anderson. He will participate in mineralogical research, particularly electron microscopy of soil clay minerals, with R. C. Jones.

REPORT OF  
NORTH CAROLINA STATE UNIVERSITY

## REPORT OF NORTH CAROLINA STATE UNIVERSITY

FOR THE PERIOD

JULY 1, 1973 TO JUNE 30, 1974

A. TITLE: A Grant to Strengthen the Capabilities of North Carolina State University in Selected Problems of Tropical Soils (Grant AID/csd 2835)

B. GRANTEE: North Carolina State University

C. DIRECTOR: Dr. P. A. Sanchez

D. STATISTICAL SUMMARY:

1. Period of Grant: November 2, 1970 to November 2, 1975
2. Amount of Grant: \$500,000.00
3. Expenditures:
  - 3.1 For report period: \$68,045.00
  - 3.2 Accumulated: \$169,585.00
  - 3.3 Anticipated for next year: \$123,000.00

E. NARRATIVE SUMMARY:

The competency of North Carolina State University as a center of expertise in soils of the tropics continues to be significantly and measurably strengthened through the financial support provided by the grant during its fourth year of operation. In addition to the previous efforts in the areas of teaching and research, the thrust of this year's activities have concentrated on utilizing this expertise in developing countries.

The principal activity of the year was to improve linkages with tropical soil scientists through 1) organizing and conducting a major

Seminar on Tropical Soils Management with participation of about 250 soil scientists, 2) conducting a post-seminar tour through key areas of South America, and 3) publishing in book form the Review of Soils Research in Tropical Latin America in English and Spanish, and 4) formulating plans for establishing a Tropical Soils Network Center as the outreach arm of the Consortium.

F. GENERAL BACKGROUND AND PURPOSE OF THE GRANT:

A grant to strengthen the capabilities of North Carolina State University in special problems of tropical soils was approved on November 2, 1970 for a five-year period. Its purpose is to increase the capability of the Soil Science Department in becoming a center of expertise for training, research, and technical assistance in soils of the humid tropics. The subject matter emphasis is on soil fertility and management; the initial geographical emphasis is Latin America. Additional efforts which contribute to the broad objective of the grant is provided by two other AID-funded activities: The International Soil Fertility Evaluation and Improvement Program (ISFEIP), Contract AID/1a 646, and a research program entitled "Agronomic-Economic Research on Tropical Soils", Contract AID/csd 2806.

Objectives of the Grant

1.1 Objectives restated

- (1) To establish a senior faculty professorial position at North Carolina State University in tropical soils to coordinate efforts of other departmental research activities in the tropics and those of the other four cooperating universities.

- (2) To provide visiting professorships through which North Carolina State University will bring additional expertise and experience from the other cooperating institutions and from other sources.
- (3) To provide graduate research assistantships for students in tropical soils in North Carolina State University degree granting programs.
- (4) To provide (a) for travel of graduate students to tropical areas for training, (b) for support of such students while overseas, and (c) for travel and support of faculty to supervise them and to consult with cooperating institutions.
- (5) To provide graduate exchange assistantships so that students of the four cooperating institutions may have access to the strengths of North Carolina State University.
- (6) To modify existing soil courses and develop new courses in tropical soils for use by AID and the personnel involved in tropical soil and crop management and related activities in the less developed countries.
- (7) Strengthen library and other information services and provide support for the preparation of training materials on soil and crop management in the tropics.

## 2. Review of the Objectives

The activities during this report period remain consistent with these objectives. No modification of the original objectives is contemplated. As the program develops, however, more emphasis is given to the utilization aspects.

## ACCOMPLISHMENTS

### 1. Staff Involvement

A large proportion of the faculty are involved in tropical soils studies. This policy permits that the increased expertise attained

through the grant is weaved throughout the fabric of the Department. During this year, 22 professors and 21 graduate students were involved in various degrees in teaching, research, and technical assistance in tropical regions. This represents 40% of the Department's faculty and 50% of its graduate students. A complete list appears in Table 1. Five faculty members and four graduate students are presently stationed overseas. They conduct research and technical assistance activities supported by the two AID contracts in Brazil, Peru, Panama, Costa Rica, and Guatemala.

Table 1. Soil Science Department staff involved in tropical soils teaching, research, and technical assistance programs.

Faculty

C. B. McCants, Professor and Department Head  
 P. A. Sanchez, Associate Professor and Project Leader, Grant csd/2835 and Contract csd/2806, tropical soils teaching and research  
 J. W. Fitts, Professor and Director, International Soil Fertility Evaluation and Improvement Program (ISFEIP) Contract la/646.  
 W. V. Bartholomew, Professor, organic matter transformations  
 S. W. Buol, Professor, soil genesis teaching and research  
 R. B. Cate, Visiting Associate Professor, ISFEIP, (Guatemala)  
 M. G. Cook, Professor and Coordinator, Academic Affairs  
 F. R. Cox, Associate Professor, soil micronutrient research  
 R. B. Daniels, Professor, soil geomorphology (USDA)  
 J. W. Gilliam, Associate Professor, analytical services  
 M. A. Granger, Research Associate, tropical soils  
 A. H. Hunter, Visiting Associate Professor, ISFEIP, soil analysis  
 E. J. Kamprath, Professor, soil fertility teaching and research  
 G. S. Miner, Assistant Professor, soil fertility teaching and research  
 J. J. Nicholaidis, Visiting Assistant Professor, ISFEIP (Costa Rica)  
 D. D. Oelsligle, Visiting Assistant Professor, tropical soils research (Costa Rica).  
 S. S. Portch, Visiting Assistant Professor, ISFEIP, (Panama)  
 G. Uehara, Visiting Professor, tropical soils  
 J. L. Walker, Visiting Associate Professor, ISFEIP (Guatemala)  
 D. L. Waugh, Visiting Associate Professor, ISFEIP  
 S. B. Weed, Professor, soil chemistry teaching and research  
 A. G. Wollum, Associate Professor, soil microbiology teaching and research

Graduate Students in Tropical Soils

A. Alvarado (Costa Rica), soil genesis (Dr. Buol)  
 J. M. Bingham (USA), soil genesis (Dr. Buol)  
 E. Gonzales (Paraguay), soil fertility (Dr. Kamprath)  
 I. F. Lepsch (Brazil), soil genesis (Dr. Buol)  
 A. S. Lopes (Brazil), soil fertility (Dr. Cox)  
 C. E. Lopez (Dominican Republic), soil fertility (Dr. Sanchez)  
 J. Mendez-Lay (Panama), soil fertility (Dr. Kamprath)  
 F. Munevar (Colombia), soil microbiology (Dr. Wollum)  
 L. Mejia (Colombia), soil genesis (Dr. Buol)  
 J. R. Paredes (Venezuela), soil genesis (Dr. Buol)  
 R. A. Pope (USA), soil genesis (Dr. Buol)  
 D. G. Rossiter (USA), soil management (Dr. Sanchez)

Table 1 (Cont'd).

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J. G. Salinas (Bolivia), soil fertility (Dr. Sanchez)  
S. M. Sertsu (Ethiopia), soil fertility (Dr. Sanchez)  
C. E. Seubert (USA), soil fertiltiy (Dr. Sanchez)  
T. J. Smyth (USA), soil fertility (Dr. Sanchez)  
F. T. Turner (USA), soil chemistry (Dr. Gilliam)  
E. J. Tyler (USA), soil genesis (Dr. Buol)  
J. H. Villachica (Peru), soil fertility (Dr. Sanchez)  
M. K. Wade (USA), soil management (Dr. Sanchez)  
R. S. Yost (USA), soil fertility (Dr. Kamprath)

Supporting Staff

Bertha Monar, Tropical Soils Program Secretary  
Cathy Langley, Laboratory Technician III  
Patrice Hill, Stenographer II

### Teaching

In addition to the regularly scheduled fall semester course on "Characteristics and Management of Soils of the Tropics," a special graduate course on the "Chemistry, Physics, and Mineralogy of Oxide Systems," was taught during the spring semester by Dr. Goro Uehara. Most of the graduate student body and many faculty members attended.

The Soil Fertility Evaluation seminar was held for its ninth consecutive year under the sponsorship of ISFEIP. Lectures were given to over 20 participants from developing countries by faculty employed under the 1a/646 and csd/2806 contracts, the 211(d) grant, and state and federal appropriations for operations of the University.

Drs. S. W. Buol and S. B. Weed participated in the Tropical Soils Mineralogy Workshop held at the University of Hawaii as a Consortium effort to strengthening teaching of this subject matter.

### 3. Visiting Scientists

Dr. Goro Uehara of the University of Hawaii joined the Department as a Visiting Professor for the period of January 1 to August 31, 1974. Dr. Uehara taught the special course mentioned in the previous section and consulted intensively with faculty and graduate students on research programs in the tropics and in North Carolina. Also he initiated studies on the role of calcium silicate on Oxisols, Histosols, and on the effects of absorbed anions on cation retention in Oxisols in cooperation with faculty members and two graduate students. Dr. Uehara provided advise for new research projects and reviewed critically the manuscript of a Tropical Soils

Management book prepared by Dr. Sanchez. His presence in Raleigh resulted in very productive interchange of stimulating ideas with faculty and graduate students. His visits to our research stations in Peru and Brazil generated several new avenues of research, particularly in the area of soil physics.

Several scientists and administrators visited the Department during the year to discuss matters of mutual interest related to tropical soils. Their visits averaged about four days and usually involved seminar presentations. During this year, the following visited the Department on matters relevant to the 211(d) grant: Mr. Chau Van Hahn, Chief of Soil Chemistry Laboratory, Institute of Research, Saigon, Vietnam; Dr. Colin Andrew, Division of Tropical Pastures, CSIRO, Brisbane, Australia; Dr. George C. Naderman, Jr., Cornell-NCSU Brazil Project; Dr. Antonio Pinchinat, CATIE, Turrialba, Costa Rica; Dr. Egon Klamt, Soils Department, Universidad Federal de Rio Grande do Sul, Brazil; Dr. David Moore, Oregon State University; Mr. Eric Bettanay, Division of Land Resources, CSIRO, Perth, Australia; Dr. Robert C. T. Lee, Chairman, Joint Commission of Rural Reconstruction, Taipei, Taiwan; Dr. Arthur Niehoff, AID Consultant and Miss Milagros Miro, University of Puerto Rico. Of this list, Dr. Pinchinat's travel was partially supported by 211(d) funds.

#### 4. Research

Two graduate students supported by the 211(d) grant obtained their degrees during the year. Dr. Michael A. Granger from Guyana completed his program in September, 1973 and joined the faculty in a post-doctoral position in charge of evaluating the fertility-capability soil

classification system. Dr. Fred T. Turner obtained his doctorate in January, 1974 after completing a dissertation on factors affecting the increase in phosphorus availability in flooded soils. Dr. Turner joined the faculty of Texas A&M University and is working on the chemistry of flooded soils at the Beaumont Station.

A third graduate student supported by 211(d) funds, Mr. Alfredo S. Lopes from Brazil, recently obtained full financial support from his country to continue his program at this University.

The 211(d) grant has been used to supplement research by faculty and graduate students in order to make their research efforts more meaningful to developing countries. During this year, 211(d) funds were used for: 1) Mr. Leonidas Mejia, a Colombian graduate student to travel to the Llanos Orientales to collect and ship samples for his thesis research, 2) shipping soil samples collected by Mr. Ramon Paredes in the Maracaibo Basin of Venezuela to Raleigh for his thesis research and 3) for Dr. R. B. Daniels to travel in Brazil and advise Mr. Igo Lepsch on his thesis research program.

Since all these projects are also partially supported by the Tropical Soils Research Contract, the research results appear in the annual report of that contract.

##### 5. Participation in International Conferences and Study Trips

Faculty travel to tropical regions supports many of the grant's objectives. It increases the individual's experience in specific tropical areas and problems; it allows him to become personally acquainted

with personnel and on-going programs at different institutions, and it often provides consultation services to the host countries. A total of 14 professors and 5 graduate students visited 15 countries during this year, spending a total of 20 man-months away from the campus. Of these, 7 professors and 1 graduate student travelled under grant support. Faculty travel within the United States to coordinate activities among the Consortium Universities was also supported by grant funds.

A summary of travel activities follows:

Drs. Buol and Weed attended a Tropical Soil Mineralogy Workshop in Hawaii for the period of July 7-22, 1973.

Dr. Kamprath attended the "III Soils Colloquium: Phosphorus in Tropical Areas" sponsored by the Colombian Society of Soil Science in Bogota during the period of August 26 to 31, 1973. He presented a paper entitled, "Chemical aspects and mineral forms of phosphorus in tropical regions."

Dean Rigney, Dr. McCants, and Dr. Sanchez attended the Annual Review of the Consortium in Washington on November 8 to 9, 1973.

Dr. Sanchez attended the annual meeting of the American Society of Agronomy in Las Vegas from November 11 to 16, 1973, and chaired a joint session between Divisions A-6 (International agronomy) and Division S-4 (Soil fertility and plant nutrition).

Mr. Leonidas Mejia travelled to Bogota and the Llanos Orientales of Colombia from December 20, 1973 until January 7, 1974. He collected soil samples along a toposequence near Carimagua and shipped them to the United States for study.

Dr. Sanchez travelled to Cali, Colombia to confer with the CIAT staff about arrangements related to the Tropical Soils Management Seminar. He also spent part of his time in Peru consulting with Ministry officials in relation to the post-Seminar tour in that country. (January 15 to 23, 1974)

Dr. Kamprath attended a symposium on "Sulfur in an Australasian Agriculture" in Canberra, Australia as a U. S. representative sponsored by the National Science Foundation from February 6 to 26, 1974. Funds from the 211(d) grant were used to visit the Division of Tropical Agronomy (CSIRO) and the University of Queensland in Brisbane and to visit the Waite Agricultural Research Institute and CSIRO offices at Adelaide. Dr. Kamprath presented a seminar on "Exchangeable aluminum as a criterion for liming highly weathered soils" at Brisbane.

Drs. McCants, Sanchez, and Uehara attended the Seminar on Soils Management and the Development Process in Latin America in Cali, Colombia from February 10 to 14, 1974. Dr. Sanchez was the Seminar Chairman. Dr. McCants welcomed the group on behalf of the Consortium. Dr. Sanchez presented two papers on "The fertility-capability classification system" and "Effects of solar radiation on rice responses to nitrogen in Peru." Dr. Uehara presented a paper on "Management implications of soil mineralogy in Latin America." Other NCSU faculty members also attended with support from other funds: Drs. Oelsligle, Granger, Hunter, Waugh, Cate, Walker, and Portch. Drs. Sanchez, Uehara, and Oelsligle participated in the post-seminar tour from February 15 to 24, 1974.

Drs. Oelsigle and Sanchez participated in a multiple cropping conference sponsored by IICA and AID in Turrialba, Costa Rica during the period from February 25 to 28, 1974.

Dr. Daniels travelled to Sao Paulo and Brasilia, Brazil to advise Mr. Igo Lepsch on his field thesis research. Dr. Daniels and Dr. Buol proceeded to Brasilia to consult with the staff of the NCSU-Cornell research project from March 30 to April 13, 1974.

Dean J. A. Rigney attended a meeting of the Consortium Council of Deans in Washington on May 7, 1974.

Dr. Sanchez attended a briefing on agricultural drought situation in the Sahelian zone at AID, Washington on May 8, 1974.

Drs. McCants and Buol attended a conference on "Experimental Design to Predict Crop Productivity with Environmental and Economic Inputs" at the University of Hawaii from May 19 to 26, 1974.

Dr. Sanchez attended an international conference on "Land Use Systems for the American Humid Tropics" in Lima, Peru on June 10 to 15, 1974, sponsored by the Interamerican Institute of Agriculture Sciences. He presented a paper on "Soil management research in the Amazon Jungle of Peru."

Dr. Uehara was invited to the University of Florida in Gainesville to present a series of seminars on the Mineralogy, Chemistry, and Physics of Soils of the Tropics, and to discuss related matters with faculty and graduate students. He was there from June 24 to 28, 1974. All expenses were paid by the University of Florida.

6. Seminar on Soil Management and the Development Process in Tropical Latin America

At the November, 1972 meeting of the Consortium Executive Committee, it was decided that the second Consortium-sponsored Seminar be held at CIAT, Colombia in February, 1974. The Executive Committee assigned the responsibility of planning and organizing the Seminar to North Carolina State University.

The purpose of the Seminar was to gather the leading working tropical soil scientists from Latin America and discuss new and relevant advances related to the title of the seminar. An additional purpose was to explore the possibilities of expediting communications among soil scientists in the tropics through creating a research network in tropical soils.

Suggestions of appropriate speakers were received from our faculty as well as from Cornell University, AID, CIAT, IICA, the Colombian and Latin American Societies of Soil Science. A Steering Committee was then formed and consisted of Drs. J. M. Spain and F. Fernandez of CIAT; L. A. Leon, President of the Colombian and Latin American Societies of Soil Science; R. Pietri of the University of Puerto Rico; T. S. Gill of AID; and P. A. Sanchez, Chairman. The committee met at Cali in April, 1973 and in Las Vegas in November, 1973. The selection of the speakers and participants and commitments to attend were made during this period.

The seminar then became a joint effort of five co-sponsoring organizations: The University Consortium on Soils of the Tropics; CIAT; AID; the Colombian Society of Soil Science; and the Latin American Society of

Soil Science. A \$ 40,000 grant was requested by NCSU on behalf of the Consortium and was awarded by AID in November, 1973 (Grant AID/TA-G 1058). The host institution, CIAT, also budgeted special funds to support part of the Seminar.

Arrangements for the post-seminar tour to Carimagua, Colombia were made with CIAT and ICA. The CIAT soil scientists planted special demonstration plots to be ready at the time of the tour. Arrangements were also made with the Ministry of Agriculture in Peru and the Peruvian Society of Soil Science for visits to Lambayeque, Yurimaguas and La Molina in Peru. Arrangements were also made with the Empresa Brasileira do Pesquisas Agropecuarias and the Instituto Agronomico de Campinas for a 1000 km bus tour from Campinas to Brasilia. The excellent collaboration of these institutions in forward planning contributed substantially to the success of this tour to key areas of South America with relevant ongoing soil research projects.

In December, 1973, Dr. Elemer Bornemisza of the University of Costa Rica-IICA accepted the responsibility for serving as Editor of the seminar proceedings.

In January, 1974, it became apparent that the number of people intending to attend the Seminar and the post-Seminar tour was over twice of that originally planned. CIAT made considerable efforts in modifying a meeting room to accommodate over 200 people. Arrangements were also made to charter larger aircraft and buses for the post-seminar tour.

A total of 209 soil scientists from 26 countries participated in the Seminar. (Table 2). Of these only 40 were supported by the special AID grant. Over 80% of the participants, therefore, were supported by their own institutions or other international sources. The AID grant, therefore, served as "seed money" for this large undertaking.

Approximately 70 scientists participated in the Colombian portion of the tour and 35 in the entire tour including Peru and Brazil. Of these 10 were supported by the AID grant.

A total of 32 papers were presented and distributed in mimeographed form in Spanish and English. The topics were organized in sessions dealing with soil classification, soil-water relations, research networks in tropical soils, soil fertility, crop adaptation to soils, soil fertility evaluation and soil management systems.

The entire group participated in working sessions organized to discuss research priorities and the means for improving communications among tropical soil scientists. The working groups unanimously agreed that "some kind of a network is needed to fill important voids and help bring about a more effective overall program." The groups suggested that "an important beginning in tropical soil science coordination has already been brought about by this seminar. It recommended that the co-sponsors of the seminar pursue the subject further by 1) contacting interested individuals and institutions, and 2) taking advantage of existing resources available within the Tropical Soils Consortium."

Table 2. Number of speakers and participants to the Seminar on Soil Management and the Development Process in Tropical America.

Country	Total Attending	Financed by AID Grant
Belgium	1	0
Bolivia	1	1
Brazil	19	11
Colombia	79	1
Costa Rica	5	4
Chile	1	0
Ecuador	7	3
El Salvador	4	1
France	1	0
Germany	1	0
Guatemala	5	3
Guyana	1	0
Haiti	1	1
Honduras	2	1
Indonesia	1	0
Japan	1	0
Nicaragua	1	1
Nigeria	1	0
Panama	4	3
Peru	11	6

Table 2 (Cont'd)

Country	Total Attending	Financed by AID grant
Puerto Rico	6	0
República Dominicana	1	1
Tonga	1	0
Trinidad	1	1
USA	26	0
Venezuela	27	2
Total	209	40

Dr. Bornemisza is presently editing the manuscripts for formal publication. It is expected that 2000 copies of English and Spanish versions of the Proceedings will be available for distribution by February, 1975.

7. Directory of Tropical Soil Scientists

At the November, 1972 Executive Committee Meeting, North Carolina State University was assigned the responsibility of developing a directory of expertise in tropical soils. A format was developed at the April, 1973 Executive Committee Meeting and a set with 72 entries was distributed to the institutions at the November, 1973 meeting. It is important to emphasize that this list includes outstanding soil scientists from developing country institutions as well as U. S., European and Japanese ones. The responsibility of assembling this information in a computerized storage-retrieval system was assigned to Prairie View A&M University.

8. Arrangements for a Tropical Agronomy Field Course

The International Agronomy Committee of the American Society of Agronomy has for some time desired to conduct a field course in tropical agronomy for teachers in the U. S. Universities with no prior experience in the tropics. Dr. Sanchez canvassed the ASA membership through an article in the "Agronomy News." A substantial number of ASA members expressed their interest in participating in such a course at their own expense. At a joint meeting between the International Agronomy Committee and the Consortium to take responsibility of

conducting the course in either Puerto Rico or Hawaii. At the April, 1974 Executive Committee Meeting, the University of Hawaii was assigned full responsibility in planning and conducting the course on behalf of the Consortium in June, 1975.

#### 9. Planning for Establishing a Tropical Soils Network Center

Considerable faculty time has been spent in developing the concept of a network center and preparing a concrete proposal to the Consortium and AID for establishing such a Center. Considerable time was also spent discussing these ideas with members of the other four Universities AID and representatives of developing countries. A proposal was developed in May, 1974 with four concrete objectives and mechanisms for achieving them. A summary of our concept of the Network Center follows. The objectives of the Center are: 1) to accelerate communications among tropical soil scientists on new advances in the field, 2) to conduct research on and promote the utilization of advances in soil science by farmers, 3) to serve as a focal point for AID and other donors seeking qualified scientists for specific functions and for developing countries requesting such assistance, and 4) to help identify additional research and training needs in tropical soils and find appropriate support to implement them.

##### 9.1 Research Network

It is proposed that the first objective be accomplished by creating a research network in tropical soils. This actually involves formalizing many of the linkages already in existence between

the Consortium and other tropical soil scientists. The operation of the research network consists of several steps:

9.11 Linkages with other institutions active in the field will be made by formal agreements. These include international organizations such as IRRI, CIAT, CIMMYT, CIP, ICRISAT, IITA, ILRAD, ILCA, and FAO; regional institutions such as IICA, CATIE, WARDA, AVRDC; the national research, training, and extension institutions of tropical countries with meaningful involvement in soils and other institutions from developed countries active in the field such as IRAT, ORSTOM, TVA, and several American, European, Australian, and Japanese Universities. Each institution interested in joining the network would be requested to send a list of individual scientists who should receive the communications and will promise to make their new research results available for distribution. One person from each institution will be selected as the network representative for that institution or subdivision thereof,

9.12 The Center will receive new publications and select the most relevant ones for dissemination to interested recipients. For example, publications dealing with significant advances in the chemistry of Oxisols will be distributed to countries which have these soils and not those with desert climates. A limited number of the most important publications

will be translated into English, Spanish, and French. A complete list of abstracts of publications received will be published periodically.

9.13 The Center will publish a Tropical Soils Newsletter several times a year in a format akin to the "Agronomy News."

9.14 The Center will organize and sponsor several regional or worldwide conferences for key soil scientists to assemble and discuss relevant advances on specific topics related to tropical soils. Regional conferences in each of the major tropical regions (Africa, Asia, Latin America) will be held on the average of every three years per region. Worldwide conferences will deal with specific topics and will be scheduled as often as necessary.

9.15 The Center will be responsible for publishing the proceedings of such conferences and its distribution.

#### 9.1 Utilization at the Farmer's Level

It is proposed that the second objective be accomplished by several activities aimed at developing realistic mechanisms for getting the information utilized by farmers.

9.21 The Center will request that cooperating institutions condense their research results into concrete recommendations to farmers. These will be circulated among the network.

9.22 Through study trips or other suitable mechanisms, the Center will request Consortium staff to identify successful utilization programs and the factors responsible for their success.

9.24 The Center will sponsor and conduct research on methodology for transferring the research information to farmers.

9.25 After this information has been obtained, the Center will promote actual utilization programs in one or two selected areas. These projects will draw on the resources of participating institutions. Outside support will be requested if appropriate.

### 9.3 Serving as a Focal Point

It is proposed that the third objective of the Center be accomplished by the following activities:

9.31 Compile and keep up to date, a Directory of Technical Expertise in Tropical Soils. This roster will be made available to individuals or institutions upon request. The Consortium staff will be requested to identify these scientists capable and interested in short or long-term assignments.

9.32 Assist AID and other donor agencies in implementing requests for technical assistance in tropical soils. The Center would facilitate and expedite such requests by identifying the institution or individual best qualified and available to provide such services. When appropriate, the Center staff may provide direct assistance.

9.33 Assist developing country institutions requesting technical assistance in tropical soils. The Center may facilitate and expedite such requests by directing them to the appropriate

funding agency and suggesting possible institutions or individuals among the network who might be interested in providing such assistance.

9.34 Assist in design and/or evaluation of new research training or utilization projects in the field or tropical soil science. The Center might help AID and other donors in evaluating proposed projects by identifying the appropriate individuals within or outside the Consortium.

9.35 Assist in the coordination of joint research projects conducted by Consortium institutions or others involved in the network. By facilitating communication at the planning stage, the Center may contribute to reducing wasteful duplication.

#### 9.4 Research and Training Programs

The Center, through appropriate members of the Consortium and the network, may be instrumental in identifying new "bottlenecks" within the network mechanism. The fourth objective may be accomplished by the following activities:

9.41 Organize study groups composed of Consortium and/or network representatives to appraise and define serious void in training, research, or utilization aspects.

9.42 Identify on a continuous basis, the priority areas of research and other restrictions in tropical soils.

9.43 Identify promising young soil scientists associated with developing country institutions working in these priority areas

for graduate assistantships in Consortium institutions or elsewhere. The Center may support when appropriate, a limited number of these graduate programs. Thesis research will be conducted in developing countries.

9.44 Provide financial support for the initial research work of these scientists when they return to their home country after completing graduate work. Small research grants or "seed money" may be given to these scientists in response to project proposals in the priority areas identified by the Center. Such a follow-up program will strengthen linkages and permit highly qualified developing country professionals to become meaningful involved in the network.

9.45 Upgrade the undergraduate teaching program in soil science of developing country institutions through workshops conducted by Center personnel. These workshops will be run by the Consortium institutions and are designed to bring key soil science teachers up to date with subject matter and teaching techniques.

9.46 Organize and provide logistical support for short-term field courses in tropical soils (Institutes). Consortium and network staff will participate in the teaching. The purpose of these Institutes would be to upgrade the knowledge of developing country soil scientists who have been away from school several years.

Suitable simultaneous translations in Spanish and/or French will be available when appropriate.

9.47 Sponsor scientist exchange between developed and developing country institutions within the network. One-to-one exchanges will be arranged in a way that a competent but relatively young soil scientist from a developing country university may spend a semester or a year at a developed country university. The university in turn will send one of its scientists to the counterpart institution at the same time. In effect this would be a reciprocal sabbatical leave.

9.48 The Center may conduct specific research programs in developing countries with its own staff in areas or circumstances where such programs cannot be handled by Consortium or other network institutions.

9.49 The Center will establish a central soils characterization laboratory to serve as a control for other laboratories desiring this arrangement and to help characterize soils from tropical areas lacking sufficient facilities.

The Center will be governed by an Administrative Board and its activities coordinated by an Executive Committee, composed of members of the five institutions. The staff would consist of a Director, Administrative Assistant, and clerical staff located at one of the participating institutions. Two additional Associate Directors and appropriate clerical staff will be housed at other institutions.

The annual core budget for operating the Center is estimated at \$ 125,000. Outreach activities contemplated for the first two years are estimated to cost an additional \$ 400,000.

#### 10. Impact of Grant-Supported Activities in Developing Institutional Capabilities

The above activities have strengthened demonstratively the Soil Science Department's expertise in soils of the tropics. The strategy of involving a major proportion of the faculty graduate students in tropical studies directly or indirectly insures a truly departmental effort. The new and modified courses plus the many seminars and informal discussions have increased the international atmosphere of the department. Study trips to new areas have substantially broadened the personal experience of the faculty and has reduced local biases caused by limited experience in one or two tropical regions. The increased emphasis on utilizing our capabilities adds a new dimension to the scope of the program.

#### 11. Utilization of Institutional Resources in Development

Since its inception, the Soil Science Department has directly contributed to the development of soil science in the tropics through various means. A summary of such contributions related to the training of graduate students for tropical areas, the North Carolina State University Agricultural Mission to Peru (Contract AID/1a 510), the International Soil Fertility Evaluation and Improvement Program (Contract AID/1a 646), and the Tropical Soils Research Contract (Contract AID/csd 2806) have appeared in the previous annual reports. During the report period many activities were geared primarily to expand the utilization aspects of our program.

### 11.1 Actual Overseas Involvement

An estimation of the degree of the total involvement of the Department in tropical soil science is the actual time spent overseas by Soil Science Department faculty and graduate students.

Table 3 shows that the Department devoted approximately 10.8 man-years in overseas assignments related to tropical soil science. Of these, 9.1 man-years were contributed by the faculty and graduate students stationed in several developing countries, some of which also devoted considerable time to assistance in neighboring countries.

The campus-based staff spent a cumulative total of 1.7 man-years in 67 short-term visits to 15 countries by 14 professors and 5 graduate students. Most of these short visits provided support for on-going technical assistance and research projects. Many of them served to establish and strengthen linkages with local soil scientists and AID Missions as well as continuing contacts with former graduate students now occupying key positions in Latin America.

Table 3. Actual overseas involvement by North Carolina State University Soil Science Department Staff for the period of July 1, 1973 to June 30, 1974. Includes personnel on AID contracts la/646 and csd 2806.

Country	Campus-based Staff		Overseas Staff	Total
	trips	man-days	man-days	man-months
Brazil	12	188	730	30.6
Peru	10	104	730	27.8
Guatemala	6	37	730	25.6
Costa Rica	7	34	670	23.5
Panama	5	34	300	11.1
Colombia	12	84	0	2.8
El Salvador	2	4	60	2.1
Nicaragua	2	4	60	2.1
Ecuador	1	3	60	2.1
Hawaii	5	53	0	1.8
Indonesia	1	35	0	1.1
Australia	1	21	0	0.7
Bolivia	1	10	0	0.3
Paraguay	1	3	0	0.1
Honduras	1	2	0	0.1
Total, trips	67			
Total, man-years		1.7	9.1	10.8

## 11.2 Publications

The following journal articles, bulletins, papers, and theses on tropical soils were published by the Soil Science Department Staff.

Those supported by the 211(d) grant are identified.

- Bartholomew, W. V. 1973. Nitrogeno del suelo en los tropicos. En Sanchez (Ed): "Un Resumen de Investigaciones Edafologicas en la America Tropical," North Carolina Agr. Exp. Sta. Tech. Bull. 219 (Spanish version):75-96.
- Bejarano, W., J. Lainez, and Sam Portch. 1974. Adequate use of fertilizers on perennial and annual crops. Seminar on Soil Management and the Development Process in Tropical America. (In English and Spanish). Mimeographed. 11 pp.
- Buol, S. W. 1973. Genesis, morfologia y clasificacion de suelos. En: Sanchez (Ed): "Un Resumen de Investigaciones Edafologicas en la America Latina Tropical," North Carolina Agr. Exp. Sta. Tech. Bull. 219 (Spanish version):1-42.
- Buol, S. W. 1973. Soil laboratory needs in tropical research. Agronomy Abstracts 1973:111.
- Buol, S. W., P. A. Sanchez, R. B. Cate, Jr., and M. A. Granger. 1974. Soil fertility-capability classification: A technical classification for fertility management. Seminar on Soil Management and the Development Process in Tropical America. (In English and Spanish). Mimeographed. 24 pp.
- Cline, M. G. and S. W. Buol. 1973. Soils of the Central Plateau of Brazil. Agronomy Mimeo 73-13, Department of Agronomy, Cornell University.
- Cox, F. R. 1973. Potasio. En: Sanchez (Ed): "Un Resumen de Investigaciones Edafologicas en la America Latina Tropical," North Carolina Agr. Exp. Sta. Tech. Bull. 219 (Spanish version):177-194.
- Cox, F. R. 1973, Micronutrients. En: Sanchez (Ed): "Un Resumen de Investigaciones Edafologicas en la America Latina Tropical," North Carolina Agr. Exp. Sta. Tech. Bull. 219 (Spanish version):199-215.
- Cordero, A. and G. S. Miner. 1974. A field research program for obtaining interpretation data. Seminar on Soil Management and the Development Process in Tropical America. In (English and Spanish). Mimeographed. 20 pp.

- Granger, M. A. 1973. Potassium characteristics, solution composition and mineral equilibria of selected soils from North Carolina and Guyana. Ph.D. Thesis, Soil Science Department, North Carolina State University. 162 pp. (Supported by 211(d) grant).
- Granger, M. A. and S. W. Buol. 1973. Application of a theoretical  $K_2O-Al_2O_3-SiO_2-H_2O$  system to pedology. Agronomy Abstracts 1973:113. (Supported by 211(d) grant).
- Hunter, A. H. 1974. New techniques and equipment for routine soil-plant analytical procedures. Seminar on Soil Management and the Development Process in Tropical America. (In English and Spanish). Mimeographed. 15 pp.
- International Soil Fertility Evaluation and Improvement Program 1972. The evaluation and improvement of soil fertility in Latin America. Annual Report Contract la-646. Soil Science Department, North Carolina State University.
- Kamprath, E. J. 1973. Acidez del suelo y encalado. En: Sanchez (Ed): "Un Resumen de las Investigaciones Edafologicas en la America Latina Tropical," North Carolina Agr. Exp. Sta. Tech. Bull. 219. (Spanish version):137-150.
- Kamprath, E. J. 1973. Fosforo. En: Sanchez (Ed): "Un Resumen de las Investigaciones Edafologicas en la America Latina Tropical," North Carolina Agr. Exp. Sta. Tech. Bull. 219 (Spanish version): 195-198.
- Kamprath, E. J. 1973. Chemical aspects and mineral forms of soil phosphorus in tropical regions. Paper presented at the Third Soils Colloquium: Phosphorus in Tropical Zones, Colombian Society of Soil Science. 14 pp. (Supported by 211(d) grant).
- Lepsch, I. F. and S. W. Buol. 1974. Investigations in an Oxisol-Ultisol Toposequence in Sao Paulo State, Brazil, Soil Science Soc. Amer. Proc. 38(3):
- Lutz, J. F. 1973. Propiedades fisicas del suelo. En: Sanchez (Ed): "Un Resumen de las Investigaciones Edafologicas en la America Latina Tropical," North Carolina Agr. Exp. Sta. Tech. Bull. 219. (Spanish version):43-51.
- Palencia, J. A., J. L. Walker, and L. Estrada. 1974. A soil fertility evaluation program. Seminar on Soil Management and the Development Process in Tropical America (In English and Spanish). Mimeographed. 23 pp.

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- Sanchez, P. A., R. K. Perrin, and S. W. Buol. 1974. Concepts of program design for soils research and information transferral in developing countries. Paper presented at a workshop on "Experimental Design for Predicting Crop Productivity with Environmental and Economic Inputs." University of Hawaii. Mimeographed. 26 pp. (Supported by 211(d) grant).
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Waugh, D. L., R. B. Cate, Jr., and L. A. Nelson. 1973. Discontinuous models for rapid correlation, interpretation and utilization of soil analysis and fertilizer response data. Int. Soil Fertility Evaluation and Improvement Program Tech. Bull. No. 7 (In English and Spanish).

Waugh, D. L., R. B. Cate, Jr., L. A. Nelson, and A. Manzano. 1974. New concepts in biological and economical interpretation of fertilizer response. Seminar on Soil Management and the Development Process in Tropical America. (English and Spanish versions). Mimeographed. 25 pp.

### 11.3 Dissemination of Information

Substantial effort was made during the year in disseminating these and other publications in the most direct fashion to the individuals who could use it most. During the year, our mailing list of tropical soil scientists and institutions receiving these publications grew to 450 entries, distributed as follows: Latin America: 279, United States: 69, Asia: 25, Europe: 21, Africa: 16, plus 30 on campus. Funds from Contract AID/csd 2806 were used for mailing these publications.

In order to make our Review of Soils Research in Tropical Latin America more widely used, a Spanish version was prepared and printed at IICA-CITIA, Turrialba, Costa Rica. The original English version was reprinted as Technical Bulletin 219 of the North Carolina Agriculture Experiment Station. Both are being distributed to our mailing list and to whomever requests it at no cost.

### 12. Other Resources for Grant-Related Activities

The Soil Science Department conducts extensive programs in four broad categories: (1) teaching, (2) research, (3) extension, and (4) international. Involved in these programs are 55 professional soil scientists (46 Ph.D., 7 M.S., and 2 B.S. degree holders) and

a supporting staff of 28 technicians and 15 secretaries, for a total full-time personnel input of 98. In addition, there are 42 graduate students working on projects within these categories. The approximate annual cost for salaries and fringe benefits for the faculty and staff is \$ 1.6 million. The annual cost for operation, other than salaries and fringe benefits, is \$ 750,000.

There is a thorough intermix of personnel activities among the four categories described above and only a small percentage are engaged totally in one category. The data in Table 1 shows that approximately 40 percent of the faculty in the department are involved in international programs that are directly related to the purpose of the 211(d) grant. Of the total cost of operating the department, approximately 30 percent is directed to activities related to the 211(d) grant; whereas the financial support from the grant is less than 3 percent of the total. These facts clearly illustrate that the University, through its Soil Science Department, has a solid base of expertise in soil science, is providing major support to sustain the base, and is involving a high percentage of the faculty in the department in 211(d) related activities. Funds provided by the 211(d) grant have been and will continue to be used to deepen, rather than broaden the base with emphasis on increasing the expertise of faculty interested and engaged in teaching, research, or extension programs related to tropical soils.

### 13. Next Year's Plan of Work

The process of further analyzing and modifying current courses offered by the department will continue to incorporate, where appropriate, subject matter relevant to tropical areas.

The following visiting scientists are expected to be in Raleigh for short-term assignments under 211(d) support: Dr. Luis E. Tergas, University of Florida, Ecuador Project; Mr. Marcelo N. Camargo, EMBRAPA, Brazil; Mr. Claude Charreau, IRAT, France; and Dr. Peter Nye of Oxford University.

Continued emphasis will be given to coordinate the activities sponsored by the 211(d) grant with those under the Tropical Soils Research Program and the Soil Fertility Evaluation and Improvement Program to insure that the expertise of the department in tropical soils is strengthened and its overall contribution to international soil science is advanced.

The main emphasis for the following year, however, will consist of developing a mechanism for implementing the function of the Tropical Soils Network Center in collaboration with the other Consortium Institutions.

**REPORT OF**  
**PRAIRIE VIEW A&M UNIVERSITY**



**REPORT OF PRAIRIE VIEW A&M UNIVERSITY**

**FOR THE PERIOD**

**JULY 1, 1973 TO JUNE 30, 1974**

**A. TITLE: A Grant to Strengthen the Capabilities of Prairie View A&M University in Relation to Soil Fertility Problems Under Savanna-Prairie Ecology (Grant AID/CSD 2836)**

**B. GRANTEE: Prairie View A&M University**

**C. DIRECTOR: Dr. James I. Kirkwood**

**D. STATISTICAL SUMMARY**

**1. Period of Grant: June 30, 1970 to June 30, 1975**

**2. Amount of Grant: \$500,000**

**3. Expenditures:**

**3.1 For report period : \$134,215.00**

**3.2 Accumulated : \$395,929.00**

**3.3 Anticipated for next year : \$104,071.00**

**E. NARRATIVE SUMMARY**

Prairie View A&M University has strengthened its capabilities in soils of the tropics under the Foreign Assistance Act of 1961, (amended in 1966) through a grant from the Agency for International Development (AID).

Efforts have been directed toward increasing the competency of the soils staff of Prairie View A&M University in the utilization of the soils of the tropics, with emphasis on soil fertility problems under savanna-prairie ecology. This is a report of accomplishments in achieving the purposes of the grant for this year.

Expansion of the graduate program in soils and supporting disciplines involved the approval of the curricula of the graduate program in

soils by the Texas Coordinating Board of Higher Education. In addition four (4) graduate students were added to the program. The graduate research efforts have been enlarged through four (4) projects dealing with problems of agricultural development. The international aspect of the grant program has given impetus to the total program in agriculture, including recruitment of undergraduates. The Resource Center has acquired approximately 150 new volumes including books, periodicals, and journals dealing with agricultural technology. The French literature acquired through our linkage with agricultural stations in Frankophone Africa, and with IRAT and ORSTOM in Paris, is being translated into English and compiled into a reference file deposited in our resource center.

Staff increased their participation in professional meetings. This year, an active part was taken in the fourth year 211(d) grant review, two (2) seminars, two (2) consultations, four (4) professional meetings, and four (4) international work-study tours and conferences.

With the cooperation of graduate students and staff from within and outside the College of Agriculture three (3) M.S. Theses, and three (3) papers dealing with soils, agricultural development, and education were published.

The information retrieval project involving the programmed acquisition, storage, and recall of soil and plant scientists world-wide has been expanded to cover more areas and more scientists.

Personal contact has been established with scientists and institutions in South and Central America and Africa. It is planned to develop these contacts into linkages where student and/or staff exchanges are

promoted or cooperative research conducted.

Future plans include the utilization of the competencies to deal with a delivery system which will bring the fruits of modern technology to the grassroot farmer. in such a manner that the innovations will be accepted and utilized within the constraints of his eco-system. This new direction was promoted by the need to utilize the staff competencies developed through the 211(d) grant for the University Consortium on Soils of the Tropics.

#### F. DETAILED REPORT

##### 1. General Background and Purposes of the Grant:

People the world over are becoming increasingly aware that limited food production is a real and dangerous problem. When the grant was initially funded, the Agency for International Development was aware that population growth, political and economic unrest and weather conditions could worsen the food output everywhere, particularly in the LDCs. By hastening the U.S. development of expertise in tropical soils a cadre of soil scientists would be formed (the Consortium) whose experience and knowledge could be used to help alleviate the growing problems of adequate food and nutrition. This wise and perceptive action by the Agency is now maturing at a time when men so trained are beginning to be called upon to serve.

##### 2. Objectives of the Grant:

The objectives of the grant have been expounded in previous reports and embodied in the grant itself. Briefly they include: increasing

senior staff and supporting personnel to faculty, provide for consultant services and work-study tours, develop an undergraduate and graduate program (teaching and research) in Soils, and strengthen library and teaching resources at the institution.

Results of four years of efforts to develop institutional competency have justified the original objectives. At this point experience and expertise developed should be synthesized for utilization in efforts to better human conditions in LDCs and the United States. The objectives should embody this concept, if not explicitly stated in the original grant, it should be recognized at this time.

In assessing its position, Prairie View A&M University feels that its main contribution should be to deliver agricultural improvement packages (modern technology modified for use under diverse conditions) to the small farmers who operate subsistence or market-subsistence farms in the LDCs.

### 3. Accomplishments:

The accomplishments will be discussed in terms of attaining the objectives stated in Section 2.

#### 3.1 Staff Additions:

No senior staff or additional supporting staff were employed during this report period.

#### 3.2 Visiting Consultants:

Mr. D. W. Levandowsky, tropical horticulturist was a visiting consultant during June and August of 1973 and February 1974. He reviewed the potentialities of the Sahel zone of Africa

for grain and nut production and methods of water con-  
servation applicable to the small farmer. In addition  
 Mr. Levandowsky, accompanied staff on a work-study tour  
 of West Africa.

The following people presented seminars to our student and  
 staff campus-wide, under the grant sponsorship:

<u>Name</u>	<u>Institution</u>	<u>Subject</u>
Dr. A. I. Thomas President	Prairie View A&M Uni. Prairie View, Texas	"The Role of the 1890 Colleges and Universities in maintaining continuous relevancy in its programs to meet the needs of society: an administration overview".
Mr. R. L. Hart Professional Recruiter	Ford Motor Company Dearborn, Michigan	"Professionalism in your Career".
Mr. Wash Allen Radio Station KCOH	Houston, Texas	"Youth's aspirations in a changing World".
Dr. George Woolfolk Chairman	Dept. of History Prairie View A&M Uni.	"The Intellectual Climate for Progressive Research".
Dr. Gwendolyn Newkirk Chairman	Dept. of Education and Family Resources Uni. of Nebraska	"Human Nutrition: Problems of a growing Population".
Dr. E. E. Burns Dept. of Food Technology	Texas A&M University College Station, Texas	"An Overview of the World Food Crises: Present and Future".

### 3.3 Information Storage:

The information storage program (ADD NAMES) and the retrieval  
 program (SEARCH) was enlarged to include another program (FIND)  
 where the name of a particular scientist can be recalled; whereas  
 in SEARCH, the recall is by discipline etc., only. Present  
 storage consist of the bio-professional data of 138 - scientists  
 working in agriculture-world-wide. Questionnaires for the

acquisition of the raw data have been sent to several institutions in South and Central America.

### 3.4 Institutional Linkage:

A relevant linkage; meaning exchange of information, personnel and/or coordinated research was established with the following institutions:

<u>Institution</u>	<u>Location</u>	<u>Involvement</u>
CIAT	Colombia, S. Amer.	Tour, Info. Exch.
Escuela Nacional de Agric.	Chapingo, Mexico	Info. Exch.
CIMMYT	El Batan, Mexico	Tour Info. Exch.
Turrialba (IICA)	C. America	Tour Info. Exch.
U. of Florida College of Agric. African Study Center	U.S., Florida	Student Recruitment and Info. Exch.
Texas A&M U.	U.S., Texas	Class Lectures Tropical World Panel
Dept. of Development Suriname	Suriname, S. America	Tour Savanna and Info. Exch. Consultant
Ministry of Agric. and F.A.O. Cameroon	W. Africa	Tour Savanna Info. Exch.
Ministry of Agric. IRAT Ivory Coast	W. Africa	Tour Savanna Info. Exch.
Senegal-Irat & ORSTOM	W. Africa	Tour Savanna Info. Exch.
ORSTOM	Paris	Conf. Info. Exch. Tour
IRAT	Paris	Conf. Info. Exch. Your
FAO - UN	Rome	Conf. Info. Exch. Tour
Ghana (U. of Ghana)	W. Africa	Tours, Info. Exch.
Kamasi, Soils Inst.	W. Africa	Tours, Info. Exch.
Nigeria (U. of Ibaden)	W. Africa	Tour, Info. Exch.

IITA	Ibaden, Nigeria	Tour, Info. Exch.
U. of Houston	U.S., Texas	Systems Analysis Info. Exch. Educ. Modules
U. of Hawaii	U.S., Hawaii	Experiment design for the transfer of technology
Texas A&M U.	U.S., Texas	Soil Survey-Work Plan Conf.
ICA	Carimagua Colombia, So. America	Tour, Info. Exch.
Int. Potato Inst.	Lima, Peru, S.A.	Tour, Info. Exch.
Ag. Res. Center	Chiclayo, Peru, S.A.	Tour, Info. Exch.
Yurimaguas Exp. Sta.	Yurimagua, Peru, S.A.	Tour, Info. Exch.
Campinas	San Paulo, Brazil, S.A.	Tour, Info. Exch.
Brazilia	Brazil, S.A.	Tour, Info. Exch.
Washington, D.C.	U.S.A.	Tour, Info. Exch.
U. of Hawaii	U.S., Hawaii	Cooperative Research Project in Phosphorus Studies

### 3.5 Workshops and Seminars:

Drs. J. Kirkwood, J. Collins, and E. Brams presented a paper and participated in a workshop held at the University of Hawaii "Experimental Design Workshop".

In addition to the above, the records, papers, and tapes of the workshop held last year in Santo Domingo were edited, translated and compiled (in Spanish) into a 222 page report which has been distributed.

### 3.6 Graduate Research:

The graduate research program has been enlarged as shown in the following Table. It lists those students who have entered

the M.S. program this year and their research activities and those who have graduated and their theses.

<u>Name</u>	<u>Country</u>	<u>Source of Funds and Amount</u>	<u>Research Activity</u>
*W. G. Abbott	USA	\$300/mo- AID	Manganese Status in Acid Texas Prairie Soils
*T. Burke	USA	\$300/mo- CSRS	Models of Western Farm Technology Adapted for LDCs
*J. Dews	USA	\$300/mo- CSRS	Vegetable Cultivation under Multiple Cropping Systems
**R. Harvey	USA	\$300/mo -AID	Characteristics of Several Soils of P.V. Experiment Station
*B. Rengaswamy	India	\$300/mo -CSRS	Innovative Small Farm Operations for LDCs
**L. Tejeda	Dominican Republic	\$300/mo- AID	Response of Tomatoes to Rock Phosphate and Superphosphate in So. Texas Soils
**Lugard Etuk	Nigeria	\$300/mo-AID/CSRS	Reforestation of Abandoned Farmland in Nigeria
*Cesar Tejeda	Dominican Republic	\$2.00/hr - AID	A Model of Competency Based Instruction for Use in the Dominican Republic
**Robert Dixon	USA	\$300/mo-AID	Zinc Movement in Prairie Soils
Hilary Maduakor	Nigeria	\$300/mo -CSRS and AID	Cadmium and Mercury Pollution of Soils and Produce: Extent, Effect, and Control
Charles Kargbo	Sierra Leone	\$300/mo- CSRS	Production of Onion Under Tropical and Sub-Tropical Environments
Normil Henry	Haiti	\$300/mo-AID	Grass-Tropical Legume Pastures

Louis Andre	Haiti	\$300/mo-AID	Soil Sodium and Maize Growth
+Donald Moten	USA	\$2.00/hr-AID	The Movement of Two Pesticides in Soils of Houston County
Robert Banks	USA	\$300/mo-AID	Protein Content of Tropical and Subtropical Forages as Influenced by Fertilize Practices

The research efforts include mission-oriented projects aimed at intensified agricultural systems. The staff always involves the graduate student in domestic projects or projects designed to solve problems of international agriculture. These are listed in Section 3.6 of this report and Section 5 of the 1972-73 Annual Report.

Publications and presentations of our research efforts during this report period are as follows:

1. Lopez, C. E., James Kirkwood. 1974. "Isolation of Microorganisms from a Texas Soil Capable of Degrading Urea Derivative Herbicides". Soil Sci. Jour. Proc. Vol. 38, No. 2.
2. Brams, E., P. Brams, 1974. "Professionalism in Agronomy: A Wider View". Journal of Agron. Ed. (Accepted for Public. 1974).
3. Brams, P., T. Shores, and E. Brams. 1974. "The Development of a Generative - Competency Based Instructional System in Agronomic Education", J. or Agron. Ed. (Accepted for Public. 1974).
4. Collins, J., J. C. Polanco, and J. Kirkwood, 1973. "Soils of the Savanna Guabatico-Dominican Republic". ASA Meeting Div. S-5 and Tech. Bull. TAES No. 3.
5. Harvey, R., J. Collins, 1973. "Characteristics of Several Soils Developed on the Sand Interiors of the Texas Coast Prairie". ASA Meeting Div. S-5.

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\*New Student

\*\*Graduate, M.S. Soils

+B.S. Graduate in Soils

6. Kirkwood, J., Y. P. Chang, 1973. "Tropical Savanna - A Potential Frontier for Increasing Food -Fiber". ASA Meeting Div. A-6
  7. Dixon, R. H. A. Mangaroo, 1973. "The Adsorption and Strength of Bonding of Zinc in Texas Soils". ASA Meetings, Div. S-2.
  8. Brams, E., J. Collins, and J. Kirkwood. "Experimental Design For Predicting Crop Productivity With Environmental and Economic Inputs", Prairie View A&M University, Prairie View, Texas.
4. Impact of Grant Supported Activities in Developing Institutional Capabilities.

As stated in preceding reports, the personnel brought to the institution under sponsorship of the grant are contributing to the development of the entire institution by enriching the curricula through the number and quality of courses offered and by assisting staff of other disciplines to develop proposals for basic and applied research. ("Remote Sensing of Grains Under Stress NASA sponsored, and The Extent of Soil Pollution Under Systems of Intensive Grazing on Texas Coastal Plain Soils, EPA sponsored). Non-agricultural students are becoming more aware of the soils program goals and are participating in our courses. Undergraduate and graduate students are becoming increasingly involved in our international work. Two students presented papers at the Agronomy Society of America National Meetings in Las Vegas, Nevada and one undergraduate holds a national office in the Student Activities Section of The ASA.

A graduate student is serving with AID in a training program as an intern with the Agricultural Section of the Technical Assistance Bureau. His development under the program has served as a stimulus to the other graduate students in agriculture.

The soils team are also involved in developing instructional innovations for the education of change agents employed in LDCs to transfer technology to the indigenous farmer.

The staff and resource center facilities are being called upon to contribute to seminars and other University sponsored programs.

5. Utilization of Institutional Resources in Development:

The library collection has been available to students and staff in other disciplines. Recently (from our library) material dealing with livestock production and pasture improvement was compiled upon request of the Ministry of Development in Suriname, S. America. In addition, the quality and extent of the materials were enriched through the cooperation of the University Consortium so that the package sent to them was quite extensive, updated, and relevant to their problem. It is believed that more exchange between the Consortium members would greatly expand the influence of the Consortium in the LDCs. Each has unique qualities which can be utilized for the benefit of people requesting technical assistance.

The School of Agriculture of the University of Sierra Leone at Njala has requested a joint project to refine a multiple cropping system for the small farmer based on work started there by members of our staff in 1968 and expanded during the visit of Mr. Chernon Karmara, agronomist at Njala College, to Prairie View A&M University soils staff. Plans for the experimental designs are now underway.

The University, upon request, distributed copies of the Proceedings of the First International Symposium of Soils of the Tropical Savanna and other publications dealing with tropical soils and international development.

A former graduate student is now engaged in research sponsored by North Carolina State University in Peru as a part of his PhD program at North Carolina State University. Two graduates are working in the

Dominican Republic, one as a private consultant in fertilizer usage to expand rice and vegetable production and the other with the Ministry of Agriculture.

6. Other Resources for Grant-Related Activities

See Table I.

7. Next Year's Plan of Work and Anticipated Expenditures

Our major efforts for the succeeding years to utilize the expertise and facilities Prairie View A&M University has developed to aid the small farmers of the LDCs when assistance is requested by a recipient country.

Efforts will consist of developing a delivery system which will bring modern adaptive research/technology to the small farmer in a way that he will accept and utilize for his benefit. The key to this system will be the para-professional who will function as an intermediate between the scientist and the farmer.

We also plan to hold workshops on Delivery Systems during the winter of 1975, meanwhile university scientists who have worked in this field will present seminars at Prairie View A&M University.

We plan to continue our work in the compilation of material from diverse sources for the inclusion into a permanent monograph on the Soils of the Savannas.

We intend to expand our resource center through the acquisition of new periodicals and sundry materials. We also plan extensive tours of the Sahel zone and the S. American savannas, work-study tours such as these are essential to the development of a delivery system within the savanna ecology in which we propose to work.

We do not intend to expand our graduate enrollment, but to

maintain our present enrollment at 10 students with the foreign students to USA ration of 1 to 1, if possible.

REPORT OF  
UNIVERSITY OF PUERTO RICO

REPORT OF THE UNIVERSITY OF PUERTO RICO

F-1

FOR THE PERIOD

JULY 1, 1973 TO JUNE 30, 1974

A. TITLE: A Grant to Strengthen the Capabilities of the University of Puerto Rico in Special Problems of Tropical Soils (Grant AID/csd 2857)

B. GRANTEE: University of Puerto Rico

C. DIRECTOR: Professor Rafael Pietri Oms

D. STATISTICAL SUMMARY:

1. Period of Grant: March 4, 1971 to March 3, 1976

2. Amount of Grant: \$500,000

3. Expenditures:

3.1 For report period: \$129,773.71

3.2 Accumulated: \$333,650.47

3.3 Anticipated for next year: \$98,200.00

E. NARRATIVE SUMMARY:

In executing grant activities during the report period, the University of Puerto Rico followed the policy guidelines developed upon implementation of the grant. Within the framework of these guidelines and in compliance with the provisions taken previously, grant funds were expended to strengthen three major areas: teaching, research, and institution building.

The grant had a marked effect on the curriculum of the Department of Agronomy as four new soils courses were added to the teaching program. Three of these were developed and are taught by new staff members whose appointments have been made possible through the grant. Encouragement by the grant director resulted in an additional new graduate course prepared and taught by a junior staff member not supported with grant funds.

Teaching conditions improved considerably on account of better laboratory facilities, availability of audio-visual equipment and an increase in library holdings which were acquired, in part, with grant funds. The grant thus resulted in the improvement of both the quantity and the quality of the University of Puerto Rico's teaching program in soil science. This is also reflected in a significant increase in the number of graduate students majoring in soils from one in 1971 to six at present.

Research efforts under the grant continued along the lines of action taken in previous years. Under the direction of the grant director, agronomic field research was conducted on the nutritional requirements of tropical food crops in two kinds of soils which represent vast areas of the humid tropics. The crops studied include yams, taniars and pigeon peas all of which are important food crops of small farmers in LDC's. Grant funds were also used to support pedological research in the area of soil classification and soil formation.

The grant further provided the opportunity for several staff members to travel in the U.S. and abroad to attend scientific meetings, participate in field trips and to visit research institutions.

An important grant accomplishment should be seen in the development of new perspectives of tropical soils by the faculty. Prior to the grant limited financial resources did not allow extensive travel which entailed a certain degree of provincialism. The grant promoted the establishment of linkages with the member universities of the Consortium as well as the development of close contacts with individuals and research institutions abroad. The University of Puerto Rico maintains excellent working relationships with the University of Hawaii and the University of Ghent, Belgium.

## F. DETAILED REPORT:

### 1. General Background and Purpose of the Grant.

The general background and the purpose of the five grants to Consortium members are stated in the first section of this report. Within that context, the University of Puerto Rico's grant is focused on the subject matter area of conservation and protection of soils of the tropics. The grant to strengthen the University of Puerto Rico's capabilities in this field was awarded on March 3, 1971 and has a duration of five years.

The purpose of this grant is to foster the development of the University of Puerto Rico's competence and response capability in the area of conservation and protection of tropical soils. In conjunction with the four grants to other Consortium members this will contribute to building and increasing the competence of United States universities in the area of tropical soils.

### 2. Objectives of the Grant

#### 2.1 Objectives restated:

- (1) Appoint a representative in a position of administrative responsibility to a program council whose function will be to provide policy and program guidance.
- (2) Appoint a project leader who will serve on a program executive committee, which will develop detailed plans of cooperation.
- (3) Reinforce existing competencies by appointment of resident and visiting staff in areas that will complement existing strengths of the five institutions.
- (4) Provide for support of students and faculty including exchanges of students and faculty to capitalize on the respective strengths of the cooperating institutions.

- (5) Make available physical resources, including office space, laboratories, equipment and other facilities and services, as well as existing staff competencies as the institution's contributions.
- (6) Develop a viable educational and research project on tropical soils and accommodate requests for training, technical assistance and consulting services as feasible and consistent with institutional resources and commitments.

## 2.2 Review of objectives:

The major objective of the grant is to create comprehensive knowledge, experience and expertise in the field of conservation and protection of tropical soils at the University of Puerto Rico. This objective is to be achieved via (1) assessing the currently existing knowledge, (2) increasing researcher competence, (3) developing an information system, and (4) increasing the capacity to conduct research as related to the subject matter of the grant.

Achievement of the stated objective requires coordinating knowledge of at least four areas of soil science: (1) pedology (classification and characterization), (2) soil chemistry, (3) soil physics, and (4) soil management. In addition, it requires supporting inputs related to climatology, crop management, water management and cultural systems.

Grant activities have, in general, been consistent with the original objectives. However, it is contemplated to revise the objectives listed above to indicate more specifically which objectives will be pursued in order to achieve the grant purpose.

### 3. Accomplishments

#### 3.1 Organization and personnel:

Since the initiation of the grant, Mr. Rafael Pietri, Professor of Soil Science, has been in charge of all grant activities. He was appointed grant director and represented the University of Puerto Rico in the Executive Committee of the Consortium of which he is currently Chairman.

As the grant proposal called for the addition of a junior staff member (an instrumental analysis specialist), the administration of the College of Agricultural Sciences was asked for funds to appoint this new member. Funds were made available from the Dean of Agriculture's office and matched with funds from the Dean of Studies' office and Miss Milagros Miró was appointed as of August, 1970. As the funds were made available for only one year, Miss Miró is now under 211(d) grant funding, as originally planned, and will continue to be so for the duration of the grant.

In July, 1971, Dr. F. H. Beinroth was transferred from the UPR's Agricultural Experiment Station and joined the staff of the Agronomy Department of the Mayaguez Campus of the University of Puerto Rico as Associate Professor of Soils. Since then, he was fully supported with grant funds. Both Miss Miró and Dr. Beinroth are now holding tenured positions.

As a result of the grant, the number of graduate students in soil science has increased significantly from one to six. Four of these are partially supported with grant funds.

### 3.2 Teaching:

The soils courses offered at the University of Puerto Rico are all geared toward tropical soils and thus indirectly support grant activities. A more direct impact of the grant on the teaching program is reflected in the development of three new courses. Miss Miró designed a new course entitled "Instrumental Analysis of Soils and Plants" (AGRO 420) and prepared a comprehensive laboratory manual for this course. Dr. Beinroth developed two new courses, "Genesis, Morphology, and Classification of Soils" (AGRO 553) and "Soils of Puerto Rico" (AGRO 554).

During the report period Miss Miró offered the course on "Instrumental Analysis of Plant and Soils" and conducted the laboratory of the graduate course "Soil Chemistry" (AGRO 607) as well as the laboratory of the course "Soil Mineralogy" (AGRO 624). Dr. Beinroth taught both of the new courses indicated above and conducted the weekly field laboratories that form part of these courses. Mr. V. Synder, a graduate student, completely revised the laboratory for the course "Introductory Soils" (AGRO 300) and taught this laboratory twice. Another graduate student, Mr. R. Caudales, taught the laboratory of the course "Soil Fertility and Fertilizers" (AGRO 308) during the first semester of the academic year 1973-1974. Both students were supported with grant funds.

From January 15 through 21, 1974, Dr. Beinroth accompanied staff and students from Cornell University on their annual Field Study Tour in Tropical Agriculture in Puerto Rico. Dr. Beinroth served as discussion leader at the soil study sites and also presented lectures on the soils of Puerto Rico.

### 3.3 Research;

The University of Puerto Rico's research activities carried out under the grant and supported with funds from it may be grouped as follows: (a) agronomic field research, (b) laboratory studies, (c) thesis research, and (d) pedologic research.

(a) Agronomic Field Research. During the report period the following field experiments were in progress:

1. Support systems comparisons in combination with foliar fertilizer application in yams (*D. rotundata*): Isabela Substation.
2. Support systems comparisons in combination with foliar fertilizer application in yams (*D. rotundata*): College Farm, Mayaguez.
3. Yam cultivar trial (*D. alata*): Isabela Substation.
4. Yam population trial (*D. rotundata*): Isabela Substation.
5. Yam population trial (*D. rotundata*): College Farm, Mayaguez.
6. Fertilizer experiments with cassava (*Manihot* spp): Isabela Substation.
7. Effect of harvesting date on cassava (*Manihot* spp) yields; Isabela Substation.
8. Cassava (*Manihot* spp) propagation; Isabela Substation.
9. Foliar fertilizer application in pigeon peas (*Cajon cajanus*); Isabela Substation.
10. Soil compaction experiments with taniens (*Xanthosoma* spp); Isabela Substation.

With the exception of experiment 10, all of the above experiments were conceived and designed by Professor R. Pietri. The field work was carried out by Dr. J. Badillo, Assistant Agronomist with the

University of Puerto Rico's Agricultural Substation at Isabela. Experiment 10 was designed by Dr. H. Lugo Mercado, Assistant Professor of Soils at the Agronomy Department. The field work for this experiment was also conducted by Dr. Badillo. Although assigned to dedicate fifty percent of his time to these experiments, Dr. Badillo's full salary was provided by the Agricultural Experiment Station as a contribution to the grant.

The field work at the Isabela Substation was carried out on an Oxisol (Coto series; Tropeptic Haplorthox), whereas the soils used at the College Farm in Mayaguez are Ultisols (Humatas series; Typic Tropohumult). The orders to which the Coto and the Humatas series belong represent vast areas in the tropics.

The experiments in progress during the report period constitute a continuation and complementation of the experiments previously conducted. The main purpose of these experiments is to assess the nutritional requirements of tropical food crops and to provide management information for farming system operating under financial and technological constraints.

Detailed reports on the individual field experiments have been prepared. Upon completion of the experiments currently in progress these individual reports will be consolidated into one comprehensive report covering all aspects and results of the field experiments. This report is scheduled to be completed by February, 1975.

(b) Laboratory Studies. As a follow-up of the field experiments, comprehensive analytical investigations have been initiated to allow a proper evaluation of the field results and to establish

correlations between crop yields, their nutritional quality, levels of fertilization and soil characteristics. Under the general direction and supervision of Professor R. Pietri, these studies are carried out by Miss M. Miró with the assistance of grant-supported graduate and undergraduate students.

A total of 871 soil samples and 1,788 plant tissue samples have been collected, indexed and prepared for analysis. The analyses to be performed on the soil samples include cation exchange capacity; exchangeable bases; exchangeable acidity; pH in H<sub>2</sub>O and KCl; determination of N, P, and K; and determination of extractable Ca, Mg, Fe, Mn, Zn, Al and Si. The plant tissue samples will be analysed for N, P, K, Ca, Mg, Fe, Mn, Zn Al, Na and Cu.

(c) Thesis research. Mr. R. Barahona, a native of El Salvador, is supported with grant funds to conduct research for his M.S. thesis. He is investigating the effect of different levels of fertilization on the chemical composition and nutritional quality of yams (Dioscorea spp). The field experiments were carried out in an Oxisol (Cotoeries, Tropeptic Haplorthox) at the Isabela Substation. Mr. Barahona has accomplished most of the analytical work and expects to have his thesis completed by December, 1974.

(d) Pedologic research. During the report period, Dr. F. H. Beinroth, spent approximately 75 percent on research. His investigations were in the field of pedology and focused on (i) soil classification, (ii) soil formation, and (iii) soil geomorphology.

(i) Soil classification. Research in this area concentrated on the comparison and correlation of soil classification systems used in the tropics; namely, U. S. Soil Taxonomy, the FAO/UNESCO Legend, the French Classification of Soils and the Brazilian System.

A study with the objective to classify the soil series of Hawaii in the FAO scheme was previously initiated in cooperation with Drs. Ikawa and Uehara of the University of Hawaii. The scope of this study was widened to include the French system because of its importance in Africa. Dr. A. Van Wambeke, University of Ghent, Belgium, was consulted for this phase of the study. A 107-page manuscript including five correlation tables has been completed and was sent to TA/AGR for publication as an AID bulletin (Technical Series Bulletin).

Further research on soil classification was conducted in connection with the preparation of an invitational paper presented at the seminar on "Soil Management and the Development Process in Tropical America," held in Cali, Colombia, in February, 1974. In this paper the main soil classification systems used in Central and South America were elucidated and the correlation of their taxa discussed. Another paper on soil classification and its potential use for purposes of agrotechnology transfer was prepared for the Workshop on Experiment Design held in Hawaii in May, 1974.

(ii) Soil formation. Since about two years, Dr. R. L. Fox and R. C. Jones of the University of Hawaii and Dr. F. H. Beinroth have been engaged in a joint comprehensive study of eleven highly weathered soils of Puerto Rico. The immediate purpose of this research is to report research data on the pedology, mineralogy, and chemistry of

representative Puerto Rican Oxisols and Ultisols. The ultimate objective is to provide detailed information for comparisons of selected soils of Puerto Rico with those of Hawaii and to relate soil classification to soil management and crop production. Part I of this study deals with formation, morphology and classification of the selected soils. Part II with their mineralogy and Part III with their chemistry. During the report period, Dr. Fox completed the manuscript for Part III and Dr. Beinroth finalized a manuscript of 127 pages for Part I. Dr. R. C. Jones is in the process of completing Part II. Negotiations with Dr. R. W. Simonson, editor-in-chief of GEODERMA, led to a tentative agreement that a whole issue of the renowned journal will be dedicated to this research.

With the cooperation of the University of Ghent, preliminary studies on the micromorphology of Puerto Rican Oxisols and Ultisols were initiated by Dr. Beinroth in July, 1973. To date, this research involved the preparation and inspection of thin sections. It provided valuable information on micromorphologic aspects of Puerto Rican soils which was formerly not available.

(iii) Soil geomorphology. The final manuscript on previously conducted geomorphic field studies on the island of Kauai, Hawaii, was completed during the report period. This paper, co-authored by Dr. F. H. Beinroth and Drs. G. Uehara and H. Ikawa of the University of Hawaii, discusses landscape relationships of Oxisols and Ultisols on Kauai. It was recently published in the Soil Science Society of America Proceedings.

### 3.4 Educational travel:

Domestic travel of grant officers to comply with administrative and executive duties within the Consortium organization are not included in this item. These trips are detailed in the fiscal report for FY 1974. The following is a chronological account of domestic and international trips of educational nature made by staff members during the report period and supported with grant funds.

In July, 1973, Dr. F. H. Beinroth travelled to Ghent, Belgium to visit the University of Ghent. The purpose of this trip was to work on the micromorphology of Puerto Rican soils and to discuss the correlation of several soil classification systems used in the tropics. Dr. Beinroth's contacts at the University of Ghent were Professor Tavernier, Dr. Van Wambeke, Dr. G. D. Smith, Professor C. Sys, and Dr. G. Stoops. While at Ghent, Dr. Beinroth also presented two seminars on the soils of Puerto Rico.

In July, 1973, Miss M. Miró and Mr. V. Snyder, a graduate student, travelled to Hawaii to participate in a Workshop on Mineralogy of Soils of the Tropics sponsored by the University of Hawaii as a Consortium activity.

In August, 1973, Professor R. Pietri and Dr. F. H. Beinroth travelled to Bogota, Colombia to attend the third Colloquium of Soils of the Colombian Soil Science Society. The general theme of this meeting was soil phosphorus; a total of 19 papers were presented on basic aspects of soil P, P-fertilization and analysis and technology of P.

In November, 1973, Dr. F. H. Beinroth travelled to Hawaii to work with staff members of the University of Hawaii on three manuscripts for publications on jointly conducted research. From Hawaii, Dr. Beinroth proceeded to Las Vegas, Nevada to attend the 65th Annual Meeting of the American Society of Agronomy. Prof. R. Pietri also attended this meeting.

In December, 1973, Dr. F. H. Beinroth travelled to Washington, D. C. to participate in a seminar on "Program Design and Management," sponsored by the U. S. Agency for International Development. The objective of this seminar was to acquaint participants with key elements of project design, the methodology of the logical framework, and the process of project evaluation. Dr. Beinroth was invited by AID to attend this workshop.

In February, 1974, Miss M. Miró, Dr. J. Badillo, Dr. F. H. Beinroth, Dr. J. Colom Aviles, and Dr. G. L. Spain travelled to Cali, Colombia to participate in the "Seminar on Soil Management and the Development Process in Tropical America," this seminar was co-sponsored by the 211(d) University Consortium on Soils of the Tropics, the Centro Internacional de Agricultura Tropical (CIAT), the U. S. Agency for International Development, the Colombian Soil Science Society, and the Latin American Society of Soil Science. Dr. Beinroth had been invited to present a paper at this seminar. All delegates of Puerto Rico participated in the post-seminar field tour in Colombia, Perú and Brazil.

In May, 1974, Miss M. Miro travelled to Athens, Georgia, Raleigh, North Carolina, and New Brunswick, New Jersey to visit the soil and plant testing laboratories of the respective universities. She also visited the laboratories of the Technicon Corporation in Terrytown, New York.

In June, 1974, Miss M. Miro and Professor Pietri travelled to Santo Domingo, Dominican Republic to attend the 22nd annual meeting of the American Society of Horticultural Sciences' Tropical Region. Professor R. Pietri presented a paper entitled, "The Influence of Different Levels of N, P, K, Mg, Ca, and Si on the Yield of Tomatoes in an Oxisols."

### 3.5 Publications and manuscripts:

#### (a) Published or in press:

Beinroth, F. H. 1973. Oxisols-Highly Weathered, Red Soils of the Tropics. In: Soils of the Southern States and Puerto Rico. S. W. Buol, Editor. South. Coop. Ser. Bull. No. 174, North Carolina State University Press, pp. 87-91.

Beinroth, F. H., G. Uehara, and H. Ikawa. 1974. Geomorphic relationships of Oxisols and Ultisols on Kauai, Hawaii. Soil Sci. Soc. Amer. Proc. 38:128-131.

Beinroth, F. H., H. Ikawa, and G. Uehara. 1974. Classification of the Soil Series of Hawaii in Different Systems. USAID, Techn. Ser. Bull. (In press).

Beinroth, F. H. 1974. Relationships between U. S. Soil Taxonomy, The Brazilian Soil Classification System and FAO/UNESCO Soil Units. Proc. Sem. Soil Management and the Development Process in Tropical America, Cali, Colombia (In press).

#### (b) Manuscripts prepared:

Beinroth, F. H. A study of highly weathered soils of Puerto Rico. Part I: Formation, morphology and classification. To be submitted to Geoderma.

Beinroth, F. H. Some considerations on soil classification and "Soil Taxonomy" in particular. Proc. Workshop on Experimental Design, Honolulu, Hawaii (In preparation).

Abrams, R., L. Cruz Pères, R. Pietri, and F. J. Julia. 1974.  
The influence of different levels of N, P, K, Mg, Ca, and  
Si on yield of tomatoes in an Oxisol. Paper presented at  
22nd annual meeting. Amer. Soc. Hort. Sci. Trop Region.

#### 4. Impact of Grant-Supported Activities in Developing Institutional Capabilities.

At the University of Puerto Rico, most of the grant impact has been on the teaching environment, involvement and perspective of faculty personnel, and on the institution's instrumental capability to conduct research.

The grant has strongly influenced the teaching program as it stimulated the addition of three new courses. By providing improved laboratory facilities, audio-visual equipment and increased library resources, the grant has favorably enhanced the quality of the teaching and learning environment. In direct relation to these improved conditions and as a result of grant-generated opportunities for graduate studies, the number of graduate students in soil science has increased from one to six since the initiation of the grant.

Research laboratory facilities were improved significantly through the acquisition of equipment for chemical and mineralogical soil analyses. Many aspects of soil research which could previously not be investigated can, therefore, be accomplished now.

The grant enabled the appointment of two new staff members. As both of them now have tenure with the University of Puerto Rico, the experience they gained in performing grant activities will continue to be available to the institution beyond the termination of the grant. Grant funds have been used deliberately to provide travel support for staff members. It is believed that this has substantially broadened the professional experience

and perspective of the faculty and reduced a certain provincial bias stemming from limited experience in other tropical regions. The grant has further promoted the establishment of contacts with scientists from the member universities of the Consortium and from abroad. This has resulted in functioning working relationships with several institutions, as evidenced by joint research projects, as well as in dialogue with domestic and foreign scientists.

5. Utilization of Institutional Resources in Development.

Through its Office of International Programs, the College of Agricultural Sciences shares and makes available to other institutions its staff competencies and physical resources. As part of this resource sharing, commitments have been made to provide technical assistance and training to less developed countries.

The University of Puerto Rico has a contract with the Regional Office for Central America and Panama of AID (ROCAP-83) which calls for graduate training in Puerto Rico of students from Central American universities. During the academic year, 1973-1974, six students from Nicaragua were in Puerto Rico on this program to pursue graduate studies.

Another term of this contract calls for sending Visiting Professors from the College of Agricultural Sciences to Central American institutions. During the academic year 1973-1974, the following staff members were on such assignments:

Dr. L. M. Cruz Perez at the University of El Salvador, El Salvador

Dr. A. Sotomayor Ríos at the "Universidad Nacional Autónoma," La Ceiba, Honduras

Dr. V. Garcia Villareal at the "Escuela Nacional de Agricultura y Ganadería," Managua, Nicaragua.

In addition to the activities channeled through the Office of International Programs, the College of Agricultural Sciences itself serves as a resource-sharing avenue. During the academic year 1973-1974, the College of Agriculture had a total enrollment of 457 students of which 47, or approximately 10 percent were foreign students. They came from the following countries: Bolivia, 1; Colombia, 5; Chile, 1; Cuba, 5; Curacao, 1; Haiti, 3; British Honduras, 2; Panama, 3; Dominican Republic, 23; El Salvador, 1; and Venezuela, 2.

6. Other Resources for Grant-Related Activities.

The grant contributes to the overall teaching efforts and teaching commitments of the Department of Agronomy of the University of Puerto Rico. As the chief goal of the grant is to strengthen the existing competency, funds provided by this grant are not used to replace existing funding of current projects. On the contrary, activities carried out under this grant are additives to existing programs of the University. In direct support of the grant, the University has been and will continue to provide the following inputs.

1. Administrative costs and utilities in all administrative offices and facilities. The basic salary of the project leader, Professor Rafael Pietri, comes from the university budget. No funds from the grant are used to cover salaries and costs of services of senior administrative officers in the College of Agricultural Sciences.
2. Access of all persons involved in grant activities to laboratories, field research facilities, and libraries. The facilities of the Agricultural Experiment Station and its substations are also available. The field research under the grant is using a six-acre plot

at the Isabela substation which is provided free of charge to the grant program. The services of the Central Analytical Laboratory of the Agricultural Experiment Station are also available free of charge.

3. Office, classroom, and other space for faculty, students and special meetings related to the grant program. In addition, the University provides to all persons involved in grant activities all services and facilities that are normally provided to regular staff and students.
4. Members of the faculty in the Agronomy Department not directly supported with grant funds, but involved in grant activities, are considered an integral part of the grant program. Their salaries constitute a university contribution to the grant.
5. Sub-professional personnel of the department are also considered an integral part of the grant program and take part in related activities although they are state-funded.
6. Budget appropriations for supplies and materials for the Soil Science section of the Agronomy Department provided through state funds have been placed under the direct control of the grant director. This follows the same line of thinking already stated in the above paragraphs; all available resources are pooled in order to use them more efficiently.
7. Dr. Badillo, Assistant Agronomist with the Agricultural Experiment Station, has been assigned to devote 50 percent of his time to the field research phase of the grant program. Dr. Badillo is entirely supported with state funds.

## 7. Next Year's Plan of Work.

### 7.1 Teaching:

As the new courses generated by the grant program have been approved by the Office of the Dean of Studies, they are an integral part of the department's teaching program and will, therefore, continue to be taught during the academic year 1974-1975. These courses will be evaluated and modified if necessary and appropriate.

Negotiations have been initiated to obtain the services of Mr. S. M. Viscasillas, Director of the Soil Conservation Service's Regional Office at Mayaguez, to assume part-time teaching responsibilities in the Department of Agronomy. It is anticipated that Mr. Viscasillas will modify and teach the course "Soil Conservation" (AGRO 401) in the forthcoming academic year.

### 7.2 Research:

Most of the agronomic field research now in progress is expected to be completed during the next year. A comprehensive report covering all aspects and results of the field experiments will be prepared. To complement the field work, the laboratory characterization of some 2,600 soil and plant samples will continue. The analytical data and the field results will be subjected to statistical analysis to establish correlations between yield levels and nutritional quality of the crop and fertilization practices and various soil parameters.

Research in the area of pedology is contemplated to comprise the classification of all Puerto Rican soil series in different soil classification systems, investigations relating forms of soil phosphorus to weathering stages and taxonomic units, and continuing

research on the micromorphology of Puerto Rican soils. The latter will be carried out in cooperation with the University of Ghent and will include thin section, porosity and microfabric studies. This research should be useful to evaluate the structural stability of selected tropical soils and their susceptibility to erosion.

Involvement of graduate students in grant activities will be expanded during the next year. Three students will initiate research on topics directly related to the subject matter area of the grant for their respective M.S. theses. One grant-related M.S. thesis now in progress is expected to be completed by December, 1974.

#### 7.4 Visiting professors:

The grant will continue to sponsor the invitation of visiting professors. Pending negotiations have resulted in tentative arrangements for two distinguished scientists to visit the Mayaguez Campus of the University of Puerto Rico in 1974. There are Dr. Goro Uehara, Professor of Soil Science of the University of Hawaii, and Mr. Marcelo Camargo, Chief Pedologist with the "Empresa Brasileira de Pesquisa Agropecuaria" of Brazil.

#### 8. Other:

No additional matters to report.