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SOIL RESOURCES AND BIOLOGICAL NITROGEN FIXATION

211(d) Supplemental Grant AID/csd 2834

Reporting Period

July 1, 1977 to June 30, 1978

Submitted to the

U.S. Agency for International Development

New York State College of Agriculture and Life Sciences

A Statutory College of the State University

Cornell University

Ithaca, New York 14853

TABLE OF CONTENTS
SOIL RESOURCES COMPONENT

		Page
A.	Title Page	1
	Title I - Soil Resources Component of 211(d) Supplemental Grant AID/csd-2834	2
B.	Narrative Summary	3
	Highlights of Accomplishments	
	In-Country Advising	
	Developing Additional Knowledge Base	
C.	Detailed Report	4
	1. General Background and Description of Problem	4
	2. Purpose of the Grant	5
	3. Objectives and Outputs of the Grant Restated	5
	4. Critical Assumptions	6
	5. Accomplishments	7
	6. Impact of Grant Supported Activities in Achieving Grant Purpose	12
	7. Other Resources for Grant Related Activities	13
	8. Utilization of Institutional Response Capabilities in Development Programs	13
	9. Detailed Work Plan - Cornell 211(d) Supplemental Grant AID/csd-2834 6-Month Extension	15
	Objective/Output 1. Broadened Knowledge Base	15
	Subject 1A. Evaluation of Soil Resource Inventories	15
	Subject 1B. Strategy for Increasing Effectiveness of Soil Surveys	17
	Subject 1C. Estimation of Soil Temperature and Moisture Regime	19
	Objective/Output 2. Utilizing Advisory Capacity (Concerning land Assessment and Soil Survey Operations)	22
	Objective/Output 3. Education and Improved Training Capacity	24
	Objective/Output 4. Linkages and Collaboration	25
	10. Involvement of Minority Personnel and Women	28
	Table I. Distribution of 211(d) Grant Funds and Contributions from Other Sources of Funding - Soil Resources	29
	Table II-A. 211(d) Expenditure Report, Actual and Projected Summary - Soil Resources	30
	Table II-B. 211(d) Expenditure Report Reporting Year Detail Soil Resources	31
	Table III-A. Requests for Assistance - Soil Resources	32, 33

TABLE OF CONTENTS

BIOLOGICAL NITROGEN FIXATION COMPONENT

	Page
A. Title II - Biological Nitrogen Fixation Component of 211(d) Supplemental Grant AID/csd-2834	34
B. Narrative Summary	35
Highlights of Accomplishments - Biological Nitrogen Fixation	
C. Detailed	36
1. General Background and Description of Problem	36
2. Purpose of Grant	36
3. Major Objectives/Outputs Restated	37
4. Critical Assumptions	38
5. Accomplishments	38
6. Impact of Grant Supported Activities in Achieving Grant Purpose	41
7. Other Resources for Grant Related Activities	41
8. Utilization of Institutional Response Capabilities in Development Programs	41
9. Six-Months Extension Plan of Work and Anticipated Expenditures	42
10. Involvement of Minority Personnel and Women	42
Table I. Distribution of 211(d) Grant Funds and Contributions from Other Sources of Funding - Biological Nitrogen Fixation	43
Table II-A. 211(d) Expenditures Report, Actual and Projected Summary - BNF	44
Table II-B. 211(d) Expenditure Report Reporting Year Detail - BNF	45
Table III-A. Requests for Assistance Received During Reporting Period - BNF	46

APPENDICES

A. Highlights of Soil Microbiology Work under 211(d) Program, July 1977-June 1978

B. Cornell/University of the West Indies Nitrogen Fixation Project Annual Report

C. Visit to World Bank, USAID and USDA - A. R. Stobbs, November 8-15, 1977

D. Report on Visit to Trinidad - H. Eswaran May 22-30, 1978

E. Report on Visit to Malaysia and Thailand - H. Eswaran January 6-27, 1978

F. Report on Visit to Port au Prince, Haiti - A. Van Wambeke July 11-14, 1977

G. Problemes relatifs au maintien de la productivite des sols, A. Van Wambeke, February-March, 1978

H. Expert Consultation on Land Evaluation Standards, Rome October 25-28, 1977

I. Inventarios de Recursos de Suelos en America Latina A. Van Wambeke, October 3-15, 1977, Lima, Peru

J. Report on Review of Soil Survey Interpretation Aspects of Comprehensive Resource Inventory Evaluation System (CRIES) of USDA, AID and Michigan State University - Gerald Olson, 1978

Attachment - 3 copies only

"Guidelines for Soil Resource Inventory Characterization (Draft, 1978)

A. Title Page

211(d) Annual Report

Date Due August 31, 1978

Date: _____

Grant title: SOIL RESOURCES AND BIOLOGICAL NITROGEN FIXATION

Grantee: Cornell University

Grant Program Directors: Drs. A. Van Wambeke

Co-Directors: M. Alexander

R. Arnold

AID Sponsoring Technical Office: Office of Agriculture

Statistical Summary:

Period of Grant: June 22, 1976 - June 30, 1978

with 6 month extension to December 31, 1978.

Amount of Grant: $450,000

Reporting Period: July 1, 1977 - June 30, 1978

Title I. Soil Resources Component of 211(d) Supplemental Grant AID/csd-2834

Soil Resources Program Director: Dr. R. Arnold

Statistical Summary:

Amount of grant allocated:	$300,000
Accumulated expenses:	$220,683
Anticipated Expenses:	$ 79,255

Report Period: July 1, 1977 - June 30, 1978

B. NARRATIVE SUMMARY

HIGHLIGHTS OF ACCOMPLISHMENTS - SOIL RESOURCE COMPONENT

Soil resource activities at Cornell are undertaken to assist LDC agencies in matching land suitability and capability to the productive needs of small farmers within their local economies, primarily through our knowledge of soil resources and their inventories.

In-Country Advising - One effective means is to directly assist government agencies. At the request of the AID/Near-East Bureau, Dr. G. Olson and E. Hardy worked with Dr. Lateef of the Yemen desk and advised the bureau further on the Yemen Arab Republic's land-use survey. An important contribution was made in restructuring the budget and schedule of operations.

Direct utilization of this staff capability enabled personnel from the Yemen Ministry of Agriculture, the Yemen AID Mission, and AID/Near East Bureau to move ahead in their deliberations about agriculture that ultimately affect the small farmer.

Developing Additional Knowledge Base - A less personal means of assisting agencies, but potentially longer lasting, related to our activities of developing methods for evaluating soil resource inventories. Such knowledge is to be assembled and disseminated to people and agencies mainly in tropical zones where decisions about mapping and using soil resource inventories are of continuing concern. A draft report, "Guidelines for Soil Resource Inventory Characterization", has been completed and is currently in the process of being reviewed by soil survey experts from developed countries and LDC's. The final text will be presented to participants at a final workshop planned for December 1978 on "Soil Resource Inventories and Development Planning". It is hoped that this report will make a large contribution to LDC governments in evaluating their existing soil resource inventory reports and also help in understanding the interactions among soil properties, land qualities, planning needs, and goals for agriculture.

An important contribution to the "Bibliography of Soils of the Tropics" was Volume III - Middle America, drafted under this grant and published by TAB/Washington. The bibliographies are based on card files of the USDA World Soil Geography Unit. These reports are distributed mainly throughout tropical areas, to government agencies and educational institutions concerned with soil geography and soil survey.

Dr. H. Eswaran, a Malaysian working at the Geological Institute at Ghent, was at Cornell as a Visiting Assistant Professor to work on the evaluation of soil resource inventories for a six month period early in 1978. Mr. Alan R. Stobbs from the Ministry of Overseas Development England, remained at Cornell for a 3 month period working on one objective of the grant, Strategies to Increase Effectiveness of Soil Surveys. Dr. Carlos Scoppa, Director of Soil Surveys of Argentina, with INTA worked at Cornell in January and February on writing a chapter on strategies of making a systematic soil survey of a country for the Soil Resource Inventory Evaluation Handbook. Throughout the year, other scientists visited the Soil Resource group at Cornell and the Senior staff initiated, maintained, or strengthened personal, in-country contacts with individuals concerned with soil resource inventories in developing countries.

C. Detailed Report

1. General Background and Description of Problem

Agricultural production in developing countries has increased only about 1.8 percent a year during the last four years while population has increased about 2.4 percent per year.

One of the major constraints in the improvement of agricultural production in developing countries is lack of adequate knowledge of soil resources and of methodologies for assessing soil resource potential. This kind of knowledge base is important to the success of intensification of crop production of soils under cultivation, opening up new lands, developing alternative cropping systems, and irrigation and drainage programs. Government policy decisions on land use can greatly affect the well being of low income farmers as well as those with more resources. Improper land use has led to degradation of substantial land areas as a result of soil erosion, salinization, deforestation, desert expansion, overgrazing, silting of irrigation reservoirs, and flooding. On the other hand, there are enough examples to show that proper management of soil resources can improve their natural productive capacities substantially.

One of the difficulties in making land use decisions is lack of soil data necessary to make good decisions. Soil resource data and evaluation are critical to almost every project involving people and land. The World Band is concerned with assessing land suitability in the planning process, that is, matching land capability to project design. Unfortunately, this kind of information is very limited in developing countries, especially in the tropics. There is some urgency in developing criteria for soil resource evaluation in order to provide alternatives to the millions of farmers who now barely subsist on marginal and submarginal lands.

The best available estimates indicate that there are about 800 million hectares of land in the tropics which are not now under cultivation but which are potentially arable. This is a larger area than is now being cultivated. Much of this uncultivated land has favorable topography and there is evidence that substantial areas have good potential for agricultural production at relatively modest costs. In addition to the extensive areas in the tropics which are not now under cultivation, most of the soils which are cultivated have produced rather poorly. There is ample evidence to indicate that improved management practices can increase soil productivity substantially.

Decisions on whether or not uncultivated lands should be utilized or how productivity can best be increased on soils under cultivation should depend to a considerable extent on the characteristics of the soil resources and assessment of their potential. Although the United States and many European countries have programs of soil resource inventory and assessment most of the LDCs do not. At present there are no established principles for assisting LDCs in evaluating their soil resources. Experts from various countries tend to transfer their own country experiences and methods rather than evaluating the local situation and helping develop schemes which are suited to specific areas. If there is no attempt to distill out the princi-

ples of soil resource evaluation to meet specific objectives, the diversity of soil inventories and assessment will continue. This reduces the potential for sharing knowledge and technology of efficient, effective soil surveys needed as first line information for land use policies which can meet both short and long-range goals for improving the productivity and quality of life for low income farmers in LDCs. The Chief of the Soil Resources Division of FAO, Dr. Dudal at a February 1975 AID-sponsored workshop on Soil and Water Management, recommended that AID give top priority to accelerating the appraisal of potential arable land on a world wide basis.

2. Purpose of the Grant

The 211(d) Supplemental Grant AID/csd-2834 has the main purpose of assisting LDC agencies to match land suitability and capability to the productive needs of the small farmer within the local economy. This purpose is being achieved by:

a. Evaluating land and land use potential;
b. Developing methods to evaluate and improve soil resource inventories.

This purpose is primarily in the utilization mode in which Cornell has a large measure of response capability which can be utilized and at the same time expanded and strengthened through activities under the grant.

3. Objectives/Outputs of the Grant Restated

The objectives of the grant are considered under five types of outputs: A) broadened knowledge base, B) building and utilizing advisory capacity, C) education and improved training capacity, D) linkages and collaboration.

A. Broadened knowledge base subjects:

1. Evaluation of soil resource inventories - Cornell has assumed primary responsibilty for developing a method of critical analysis of soil resource inventories that will identify and qualify, as far as possible, those characteristics that determine and define successful inventories made for specifice purposes. A manual, "Guidelines for Soil Resource Inventory Characterization", will enable LDC soil scientists and knowledgeable administrators to evaluate and classify their soil inventories. Technical reference documents of the many factors involved will also be available for interested education and action-oriented institutions upon completion.

2. Strategy for increasing effectiveness of soil surveys - A viable working model to develop strategies for soil surveys involves creating awareness and understanding of the interaction of the fundamental features of soil surveys and various constraints on the overall effectiveness of such programs. A procedure for recognizing types of constraints and alternative trade-offs for establishing realistic and meaningful objectives will be outlined. The major product will be a report to enable planners and soil scientists to design acceptable strategies for improving soil surveys. Technical reference materials will also be available for increasing educational and action-oriented institutions.

3. Bibliography of soils of the tropics - There are some 12,000 bibliographic cards on file at the Soil Geography Unit of the USDA Soil Conservation Service which include references to maps and texts on charac-

teristics, classification, distribution, environment, and use of soils in all countries of the tropics. It is important for the purpose of the grant to make this information more widely available. A volume on Africa was prepared under the previous 211(d) grant. These volumes will provide a valuable reference for soil scientists and others concerned with the tropics, facilitate communication. alleviate duplication, and extend awareness of available knowledge.

B. Building and Utilizing Advisory Capacity

Visits by pedologists to the Cornell campus and Cornell staff visits to on-going survey projects will help us maintain a knowledge base to assist others when requested. Advisory services for soil resource inventory research and operational problems of soil survey will utilize existing competency.

C. Linkages and Collaboration

Continued collaboration and cooperation with CST members will be through executive meetings each year and participating in joint workshops. Short visits were to be made to AID missions in Yemen, Haiti, Philippines, Thailand, to discuss projects of mutual concern and invited specialists were to help orient staff activities to better respond to requests for technical assistance. Short visits to learn and share viewpoints with AID/Washington regional and technical assistance personnel were to benefit the grantee and sponsor and lead to increasing utilization of capacities and capabilities of all concerned. Many new and renewed contacts were made during this reporting period and are further discussed under "Accomplishments."

4. Critical Assumptions

To achieve the purposes of this grant, the following are assumptions, restated beyond the control of Cornell:

a. LDCs will collaborate in developing methods of critical analysis of their surveys and in developing strategies to improve the effectiveness of soil resource inventories,

b. AID and other donors will assist in generating requests for utilization of the added knowledge and strengthened response capabilities in soil resource evaluation,

c. Qualified soil scientists and planning personnel of LDCs will participate in planned workshop on soil resource inventories,

d. The other CST institutions will collaborate in the joint activities proposed for soils resources evaluation, and

e. Cornell University with AID and other technical assistance agencies support will work jointly to develop and implement follow-up activities to improve soil resource evaluation.

5. ACCOMPLISHMENTS

A. Broadened Knowledge Base

[redacted] Soil Resource Inventories.

The Cornell Soil Resource Inventory Study Group devised, tested, and discarded or improved procedures to measure soil map parameters that can be used in standardizing relative comparisons of soil inventories. Background information and the proposed procedures, now in draft form and being sent out to experts for review, will be the basis for a published "Guidelines for Soil Resource Inventory Characterization".

A soil resource inventory map and report may be assessed several ways. One of the most important evaluations, aside from the esthetics of data presentation or ease of understanding the soil survey report, involves an assessment of the kind and quality of information of the soil map and soil survey report. This information provides the necessary background data for the use of a soil survey for a specific objective. The most important information in a soil resource inventory is based on four components of the soil map.

The first component is defined as map unit composition. Map unit composition refers to the extent to which limiting soil properties, for a specific land use objective, are given in descriptions of map units by morphological and analytical data, land capability classifications, interpretation tables and other. If limiting or critical soil properties are not mapped or described or cannot be reasonably inferred in some part of the text or legend the value of the soil map is greatly reduced in terms of making performance predictions for a specific land use.

The second component of soil resource inventory map information concerns the density of soil boundaries on the soil map. For purposes of simplicity the soil boundaries component will be analyzed according to the sizes of delineations and the published scale. This has also been designated as map texture; and it is a measure of intensity of mapping.

The third component of soil resource inventory which will be assessed is the quality (accuracy of location and amount of ground control) of the base map. Base maps should provide enough landmarks to permit location points on the ground at levels of accuracy commensurate with the level of detail of the soil legend and the type of planning.

Finally the fourth component of information which should be assessed is the degree of accuracy and truth with which the geographic distribution of map unit delineations and boundaries are represented. This component is also known as ground-truth checking.

It should be emphasized that all of the four informational components listed above will be assessed against a background of specific land use objectives in an effort to increase the effectiveness of soil surveys for practical applications.

For each soil survey report that is evaluated, a computer listing is obtained that provides bibliographic information about the report and the parameters used for its evaluation.

Also, a computer storage system is operational that permits storage and retrieval of information about soil maps based on common properties such as the country they represent or their author. The retrieval is accomplished by using the Integrated Scientific Information System (ISIS) developed by the Swedish Agency for Administrative Development. For each soil survey report, the following information is stored in the ISIS system: (1) country, title, author, date, map scale and area of the report, (2) the type of maps accompanying the report (climatic data, present land use, etc.), (3) map parameters such as the average-size delineation and index of maximum reduction, and (4) bibliographic information such as the number of pages in the report and its publisher. This ISIS program can also accomodate information such as symposium reports and reference materials about soils.

The evaluation of a soil survey report thus is a sequential process and involves first the measurement of map parameters, the calculation of the cartographic parameters, and the input of data into the information storage and retrieval system; at this date approximately 210 maps have been analyzed with this system.

2. Strategy for Increasing Effectiveness of Soil Surveys.

Two visiting scientists, Dr. C. Scoppa, Head of the Soil Survey Unit of the Instituto Nacional, Technologia Agricola of Argentina and Mr. A. Stobbs of the Land Resources Division/Directorate of Overseas Surveys of the United Kingdom worked on setting down some guidelines for soil survey strategies. A draft report will be compiled from their reports. However, more detailed guidelines or a manual would take a longer period of work and study than the grant allowed.

3. Bibliography of Soils of the Tropics.

Volume III of the bibliography: Tropics in General and Middle America and West Indies was published during this reporting period. Publication and major distribution costs will require additional support.

B. Building and Utilizing Advisory Capacity

Cornell's advisory capacity was enhanced by advisory visits of several Soil Resource Inventory staff members to LDC agencies, international conferences, USAID offices and others.

Dr. Armand Van Wambeke, Professor of World Soils, visited Argentina in 1977 as a soils consultant. Although the trip was sponsored by FAO, new contacts and linkages were made (Dr. C. Scoppa of Argentina contributed later to the Soil Resource Inventory Project). The terms of reference for the Argentinian visit were as follows:

1. To establish the feasibility of setting up a soil data bank for the Argentine soil survey, cooperating with the Project, using locally

available facilities, and to advise on the practical usefulness and advantages of a soil data bank.

2. To advise in the setting-up and preparation of a soil data bank and in particular advise on the selection and quantity of data to be entered for short-term and long-term application for purposes of soil correlation, soil survey interpretation, land evaluation and land management.

3. To advise on the linkage of the soil data bank with the climatic data bank and with the land management data bank, to be set-up separately under the Project.

4. To perform relevant duties under the project, as required.

Early in 1978 Dr. Van Wambeke also participated in a conference concerning the improvement of agriculture in the Sahelian zone of West Africa. The conference was held in Mali. A copy of the report submitted to the conference by Dr. Van Wambeke may be found in the Appendix to this report.

Drs. A. Van Wambeke and B. Dethier attended the Expert Consultation meeting on Land Evaluation Standards in Rome, October 1977, sponsored by FAO. Both participated in the general sessions and served in group discussions out of which recommendations were made in several different areas. The recommendations and a list of participants are attached. This meeting also offered an opportunity for CU staff to strengthen linkages with representatives of other agencies and organizations and interact with other participants.

Dr. Van Wambeke participated in another FAO sponsored conference in October 1977, in Lima, Peru on the conservation and maintenance of soils in Latin America. A report submitted by Dr. Van Wambeke to the conference is found in the Appendix.

Dr. Van Wambeke and Mr. T. R. Forbes visited the USAID mission and officials of the Ministry of Agriculture in Haiti in July 1977. They were attempting to test the feasibility of setting up a possible field exercise in Haiti to evaluate existing soil resource inventories. A report on their findings is included in the Appendix.

The advisory capacity under the 211(d) grant was further strengthened in March 1978 by Drs. G. Olson and E. Hardy who were selected by the Office of Agriculture, Development Support Bureau of USAID to review the comprehensive Resource Inventory and Evaluation System (CRIES). Their evaluations were in general favorable to CRIES although they recommended that more emphasis be placed on increasing knowledge of the soil resource base and emphasized increased usage of remote sensing capabilities in the project.

Drs. Olson and Hardy were also asked to advise the Near-East Regional bureau on the Yemen Arab Republic's land-use survey. They made an important contribution in restructing the proposed budget and schedule of operations.

Dr. H. Eswaran, a visiting professor from the Geological Institute of the University of Ghent in Belgium, made two important trips in an advising capacity for 211(d). In January 1978 Dr. Eswaran visited Malaysia and Thailand to make preliminary arrangements for the proposed International Workshop on Soil Classification. His report is included in the Appendix. Dr. Eswaran also visited the University of the West Indies in Trinidad upon the request of Professor N. Ahmad (Head of the Department of Soil Science) 1) to evaluate the current status of the Soil Science Department, UWI, to perform soil micromorphological research, 2) to examine the status of soil survey investigation in the Caribbean region, especially with respect to the application of Soil Taxonomy (3) to examine and sample some soils in the field on which the Cornell Biological Nitrogen Fixation field trials were laid out. Dr. Eswaran's full report is included in the Appendix.

Mr. A. R. Stobbs of the Land Resources Division/Directorate of Overseas Surveys of the United Kingdom, a visiting scientist under the 211(d) grant, contacted the World Bank, USAID and USDA to discuss: 1) strategy for soil surveys and 2) the location of soil surveys which form part of development projects and are not published separately. Mr. Stobbs made this visit to Washington, D.C. as part of his effort to compile a report for Soil Resources on strategies of soil surveys. His report is included in the Appendix.

Drs. R. W. Arnold and H. Eswaran visited the Central University and Ministry of Agriculture of Venezuela in July 1977. Both gave seminars at the University and participated on a field trip to observe soil problems. Dr. Eswaran collected soil samples for micro morphological studies.

Soil resource inventory staff participated in the International Soil Science Society Conference in Edmonton, Canada in June 1978, papers presented include:

"Reliability of soil survey maps: Some underlying concepts", by R. W. Arnold; "The soils of the lowland rainy tropical climates: Their inherent limitations for food production and related climatic restraints", by F. R. Moormann and A. Van Wambeke; "The alteration of plagioclases and augites under differing pedo-environmental conditions", by H. Eswaran, (visiting at Cornell); and "Effects of activities of the ancient Maya upon some of the soils in Central America" and "Observation on dryland saline seepage in several countries and the causes, effects and curses", both papers by G. W. Olson.

Soil resource inventory staff members R. W. Arnold, A. Van Wambeke, G. Olson and T. Forbes also participated in December 1977 in the American Society of Agronomy Meetings in Los Angeles.

Dr. Ruth Young of the Department of Rural Sociology at Cornell University represented Cornell on the behalf of 211(d) at the Prairie View Workshop early in 1978.

Drs. Van Wambeke and Metz attended the Consortium Reorganizational meeting in Houston, Texas in July 1977, as Cornell's representatives.

C. Linkages and Contracts

Cornell is one of the five institutions associated with the University Consortium on Soils of the Tropics and has maintained and strengthened their relationship with the other Consortium Universities during this reporting period. Listed below are those agencies and institutions with whom new and renewed contacts have been made during this reporting period concerning the soil resource component of this grant:

IITA
CIAT
CIMMYT
CIDIAT
AID/Manila
University of the Philippines at Los Banos
International Rice Research Institute (IRRI)
Bureau of Soils, Manila
UNDP/FAO Land Evaluation and Training Project, Manila
Peace Corps in Philippines
U.S. Overseas Mission in Thailand
Ford Foundation (Thailand)
RED
Thailand Government Dept. of Technology and Economic Cooperation
The Rubber Research Institute in Malaysia
Department of Agriculture, Soils Division in Malaysia
Universiti Pertanian, Malaysia
OPAI (Officina de Proyectos Agricolas Integrales) Venezuela
Ministry of Public Works, Division of Soils, Caracus
CORPOANDES, Venezuela
ORSTOM, France and Ivory Coast
Soil Research Institute at Kumasi, Ghana
Kenya Soil Survey Project, National Agricultural Laboratories, Nairobi
Service National des Sols, Bobo-Dioulasso, Upper Volta
FAO, Rome
Ministry of Overseas Development, England
Agricultural University at Wageningen, Netherlands

The CST NEWLETTER, a quarterly Consortium publication has been well received and is growing in circulation. Material related to broadened knowledge base, research, conferences, workshops, seminars, and projects of interest to those in the international agricultural field is sent to Cornell where it is edited, printed, and distributed according to assigned areas by the individual Consortium members. Approximately 1250 copies are distributed by the Consortium universities to the following areas:

Cornell University	Mexico, Francophone Africa, Europe, USA
Prairie View A&M	English speaking African countries
North Carolina State Univ.	South America
University of Hawaii	Asia
University of Minnesota	Mediterranean area and North Africa
Puerto Rico	Central America and Caribbean
AID/Washington	
FAO	

6. IMPACT OF GRANT SUPPORTED ACTIVITIES IN ACHIEVING GRANT PURPOSE:

The grant's purpose is to develop systems which are adequate to evaluate the utility of existing soil surveys, and to suggest alternative methods to produce new ones. The goal is to train people to use these systems where adequate. How far have these objectives been accomplished?

A. Evaluation of Soil Resource Inventories

A soil resource inventory map and report may be assessed several ways. One of the most important evaluations, aside from the esthetics of data prsentation or ease of understanding the soil survey report, involves an assessment of the kind and quality of information of the soil map and soil survey report. This information provides the necessary background data for the use of a soil survey for a specific objective. The most important information in a soil resource is based on four components of the soil map.

The first component is defined as map unit composition. Map unit composition refers to the extent to which limiting soil properties, for a specific land use objective, are given in descriptions of map units by morphological and analytical data, land capability classifications, interpretation tables and others. If limiting or critical soil properties are not mapped or described or cannot be reasonably inferred in some part of the text or legend the value of the soil map is greatly reduced in terms of making performance predictions for a specific land use.

The second component of soil resource inventory map information concerns the density of soil boundaries on the soil map. For purposes of simplicity the soil boundaries component will be analyzed according to the sizes of delineations and the published scale. This has also been designated as map texture; and it is a measure of intensity of mapping.

The third component of a soil resource inventory which will be assessed is the quality (accuracy of location and amount of ground control) of the base map. Base maps should provide enough landmarks to permit location points on the ground at levels of accuracy commensurate with the level of detail of the soil legend and the type of planning.

Finally the fourth component of information which should be assessed is the degree of accuracy and truth with which the geographic distribution of map unit delineations and boundaries are represented. This component is also known as ground-truth checking.

It should be emphasized that all of the four informational components listed above will be assessed against a background of specific land use objectives in an effort to increase the effectiveness of soil surveys for practical applications.

A draft report, "Guidelines for Characterizing Soil Resource Inventories" has been written by members of the Soil Resource Inventory Group (three draft copies will be attached to three reports only, due to the voluminous nature of the report, interested persons should consult one of the copies).

B. Strategies for Soil Resource Inventory Operations

Two visiting scientists, Dr. C. Scoppa, head of the soil survey unit of the Instituto Nacional Technologia Agricola of Argentina and Mr. A. Stobbs of the Land Resources Division/Directorate of Overseas Surveys of the United Kingdon worked on setting down some guidelines for soil survey strategies. A draft report will be compiled from their reports. How close the accomplishments stand against the final purpose is difficult to assess. To produce a complete Handbook devising methods which provide guidelines for soil survey evaluation and covers all phases of the inventory operation will probably be impossible to achieve during the rest of the grant. At least five years of research activities would be needed.

C. Bibliography of Soils of the Tropics

The work on this project component has progressed normally. It is felt that it will serve an extremely useful purpose in retrieval of information which is a time consuming process in land development planning in LDC's.

The distribution of Volume III Middle America and the West Indies will reach a large number of individuals and institutions, and contribute in achieving the purposes of the grant's objectives.

7. OTHER RESOURCES FOR GRANT-RELATED ACTIVITIES

The financial plan indicates the amount of other funding that relates to satisfying the 211(d) grant purposes. The University commitment includes 75-80% of the salaries of State-supported professors, and a large percentage of a work year advising and consulting services of other senior staff. Fringe benefits and overhead not included in University services are provided by the University based on salaries and wages. A small amount for library acquisitions related to the grant purpose are also included. Tuition of $1000/year is waived by the College for Graduate Assistants supported under the grant.

Important sources of outside funding are stipends awarded students from LDCs and other countries whose academic programs are directly related to the grant purposes. At present there are students supported by Venezuelan government fellowships, several receiving support from AID, and others on Rockefeller or other fellowships. We assume that such outside funding will continue at the same level in the future.

The full-time state supported professorship in world soils insures continuity for future activities beyond the grant. Discussions with FAO and other potential sponsors indicate promise of support for continuing the activities of the grant objectives.

8. UTILIZATION OF INSTITUTIONAL RESPONSE CAPABILITIES IN DEVELOPMENT PROGRAMS

Personal interaction with AID Missions and LDC organizations conducting soil research and soil surveys provide the opportunities to share experiences

and concerns about soil resource inventories and their evaluation. During this reporting period senior staff received requests for assistance from the following institutions:

AID/Near-East Bureau - Drs. G. Olson and E. Hardy worked with Dr. Lateef at the Yemen desk. They advised the bureau further on the Yemen Arab Republic's land-use survey. An important contribution was made in restructing the proposed budget and schedule of operations.

Other requests for assistance were received from the following institutions:

A. INTA (Instituto Nacional Technologia Agricola (Argentina)) -Request to establish feasibility of setting up soil data bank for the Argentine soil survey and the linkage of the soil data bank with the climatic and land management data bank.

B. Soil Department of the University of the West Indies - Request to evaluate feasibility of micromorphological research at UWI and soil survey in the Caribbean region.

Visiting scientists with broad tropical experience contributed through seminars and discussions and conferences with staff and students. Among the visiting scientists who contributed to the overall objectives during this period include Dr. M. Laker[1] from the University of Fort Hare, Cape Province, South Africa; Dr. Hari Eswaran[2] from the University of Ghent; Professor D. R. Tavernier, Soil Scientist, University of Ghent; Dr. P. Herbillon from the University of Louvain le Neuve, Belgium.

During the remainder of the grant, and after the grant expires, Cornell plans to provide the Methodology to LDC governments for evaluating the status of Soil Resource Inventories and make available the Handbook that will provide guidelines to have these evaluations carried out by LDC institutions. It is expected that many LDCs in the tropics will have to assess their capability in measuring the potential of their soil resources. We expect that these problems will become more and more important in the next few years because most tropical countries are dependent for their agricultural development on their own resources and with the rising prices of fertilizer, the quality of land will be one of the most critical production factors.

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[1] Directly supported by 211(d) funds.

[2] Directly supported by 211(d) funds.

DETAILED WORK PLAN - CORNELL 211(d) SUPPLEMENTAL GRANT AID/csd-2834 - 6 MONTH EXTENSION

Objective/Output 1. Broadened Knowledge Base

Subject 1A. Evaluation of Soil Resources Inventories

Relevance to Grant Purpose

Throughout the world there are many types of land evaluation methods and approaches being carried out. Many complex land use decisions are being made in LDCs. Land development schemes and projects, especially those affecting small farmers, should have realistic objectives that match the suitability and capability of the lands being considered if efficient and effective use of resources are to be realized. Are the inventories and appraisals well suited to the needs, stated or implied, of the anticipated land use plans?

With perhaps about one-half of the world's potentially arable lands still waiting additional evaluation, we believe that a procedure for evaluating soil resource inventories will be of valuable assistance by:

(a) facilitating communication among agencies, institutions and organizations involved in development processes where land resources are an integral component of that development,

(b) hopefully reducing duplication of effort in assessing various inventories and appraisals,

(c) focusing on essential items and minimal data required to meet specific objectives, and

(d) indicating components that need additional research or collaborative studies to be more useful indicators in inventories and appraisals.

It is not the intent to provide a detailed listing of all available soil resource inventories in LDCs of the tropics as this is more nearly a function of FAO, or other organizations. It is the intent to provide a system or method to evaluate properties of soil resource inventories most relevant to planning land use.

I. Activities or Work to be Performed.

A. 6 Month Extension (year three)

1. Distribute guidelines for evaluating soil resource inventories for external review. Research Associate.

2. Compile and edit revision for the guidelines in preparation for publication. Staff

3. Conduct workshop combining methodology of SRI evaluation and strategies for planning. (described under Subject 1B). All Staff.

B. Beyond the Grant.

1. Conduct follow-on testing and training in LDC's at the request of AID administrative units. Expected to combine methods of SRI evaluation and strategies for designing new inventories.

II. Staff to be Involved.

A. Armand Van Wambeke, Professor of Soil Science
B. Richard W. Arnold, Professor of Soil Science
C. Gerald W. Olson, Associate Professor of Soil Science
D. Terence Forbes, Research Associate

III. Scheduled Events/Targets

A. 6 Month Extension (year three)

1. External review of "Guidelines for Evaluating Soil Resource Inventories" by experts in US, Europe and LDCs. Compilation of responses during second quarter.

2. Reorganized and re-edited "Guidelines" summarized for publication. By end of second quarter.

3. Summary report on status of Computer Catalog of soil maps and reported evaluation. End of second quarter.

4. Component part of Workshop on evaluation and improved strategy of soil resource inventories. During second quarter.

B. Beyond the Grant - same.

IV. Expected Results - 6 Month Extension (year three)

A. 6 Month Extension

1. Revised "Guidelines for Evaluating Soil Resource Inventories" ready for publication.

2. Summary Information about the computerized storage and retrieval program that handles soil surveys.

3. Completion of Workshop in December. A small group of people trained in use of evaluation methodology.

V. Estimated Costs

	6 Month Ext
Salaries & Benefits	22,000
Travel	2,929
Supplies	600
Publications	455
Other	112
	$26,095.

VI. Summary of Results Expected from Methods of Evaluating Soil Resource Inventories

A system of classifying the many kinds of soil resource inventories will highlight those characteristics that determine and define successful inventories made for specific objectives. The guidelines will enable knowledgeable administrators to assess existing or proposed soil inventories. The Guidelines for Evaluating Soil Resource Inventories can be reproduced by AID for distribution.

Preliminary testing and training of people in the use of the Guidelines will be done during the proposed final workshop. Follow-on training and application of inventory evaluation is envisioned to be done in conjunction with training in the development of strategies for improving the effectiveness of soil surveys. Current manpower, time, and financial support is not sufficient to conduct further testing in LDCs during the grant period.

Subject 1B. Strategy for Increasing Effectiveness of Soil Surveys

Relevance to Grant Purpose

Effectiveness of soil surveys involves three main aspects: (1) efficiency of effort and finances used to produce the survey information, (2) accuracy or correctness of maps and associated data which may be called quality of the survey, and (3) usefulness or utility of the product for users of the inventory and appraisals.

Many types of soil surveys are produced in LCDs and throughout the world. They are often made for one limited objective such as irrigation suitability but contain information that would satisfy other objectives such as community development, road location, and so forth. Based on experience with some soil inventories it is believed that the effectiveness of surveys can and should be improved whenever and wherever possible. Strategies for improving surveys must be guided on one hand by sound theoretical considerations of the basic features of soil surveys, and on the other hand by constraints imposed on such activites. The interaction of the institutional, social, and political contraints with desires for certain kinds of information using known methodologies for providing soil survey data lead to alternative solutions or compromises. Misunderstanding by both planners and pedologists of what is wanted or needed and the means of obtaining the appropriate information was quite vividly brought out by the AID-sponsored seminar held in January 1976 at Hyderabad, "The Uses of Soil Survey and Classification in Planning and Implementing Agricultural Development in the Tropics" This study will attempt to design alternative strategies for increasing the effectiveness of soil surveys relative to the constraints that are to be considered. It is the intent to provide material that can serve as a guide for assessing and making recommendations on appropriate strategies for specified objectives, and also provide a basis for further research/training.

I. Activities or Work to be Performed.

A. 6 Month Extension (year three)

1. Edit or revise materials on soil survey strategies provided by specialists. Senior staff and Res. Assoc.

2. Prepare materials for workshop. Putting together a package of how to use the Guidelines. Res. Assoc., Grad Assistants and Senior staff.

3. Conduct a workshop dealing with Soil Resource Inventory Evaluation and Soil Information needs of Planners. Expected to be 5 day conference with 30 people (5-10 from LDCs). This is in conjunction with item under Output 1A. All staff.

B. Beyond the Grant

Conduct follow-on testing and training in LDC's as requested by AID administrative units. Such activities would be a package of inventory evaluation and strategies for improving their effectiveness. It is not thought possible to carry out this important utilization within the time span or financial support of the grant.

II. Staff to be Involved - 6 Month Ext (year three)

A. Armand Van Wambeke, Professor of Soil Science
B. Richard W. Arnold, Professor of Soil Science
C. Gerald W. Olson, Associate Professor of Soil Science
D. Terence Forbes, Research Associate

III. Scheduled Events/Targets

A. 6 Month Ext (year three)

1. Publication of background materials on survey strategies, probably as Agronomy Mimeos. Early in second quarter.

2. Workshop to explain procedures and materials used in evaluating soil resource inventories and in developing strategies. Second quarter.

IV. Expected Results

1. Selected reference material on strategies of soil surveys available as Agronomy Mimeos.

2. A small group of people acquainted in the rationale and methods of evaluating kinds of inventories.

3. Materials compiled for proceedings of the Workshop.

B. Beyond the Grant

We believe that a major item affecting the small farmer is the set of decisions that determine or establish land use policy. When such decisions are based on a better understanding of soil and land qualities expressed in soil resource inventories, the total economy usually benefits greatly in the long run. Communicating the right information at the right time in a proper manner may be pivotal to many land use policies. The development of, and training in, procedures for evaluating soil resource inventories and designing ways to improve their effectiveness is the key element of our work that we believe leads to the type of communication that provides for better tomorrows.

V. Estimated Costs

	6 Month Ext
Salaries & Benefits	$ 15,000
Travel	8,000
Supplies	710
Publications	1,000
Other	
	$24,710

VI. Summary of Results Expected from Strategies for Improving Effectiveness of Soil Surveys

A model for developing strategies for soil surveys involves creating an awareness and understanding of the interaction of the fundamental features of soil surveys and of various constraints on the overall effectiveness of such programs. It is thought that mutual understanding and awareness by planners and soil survey administrators are necessary to improve survey effectiveness. Some guidelines could be produced by AID for distribution.

Follow-on application and training in developing strategies are envisioned to be undertaken jointly with training in the application of the method of evaluating soil resource inventories. Current manpower is not sufficient to conduct proper testing in LDCs during the grant period.

Subject 1C. Estimation of Soil Temperature and Moisture Regime

Relevance to Grant Purpose.

FAO and other groups have been trying to develop agro-climatic zones throughout the world as one means of interpreting and extrapolating agricultural experiences from one part of the world to another. Soil Taxonomy relies on measurements or estimates of both soil temperature and soil moisture regimes. Application of Soil Taxonomy in many LCDs indicates a lack of interpreted information and lack of refinement of data consistent with the experience of people living in those areas.

A computer program that estimates soil temperature and soil moisture regimes from existing meteorlogical data assists countries evaluate their

avaiable information. It forms a basis for using and modifying Soil Taxonomy in an effort to improve the use and development of appropriate agricultural technologies.

I. Activities or Work to be Performed

A. 6 Month Ext (year three)

1. Review and edit existing program for errors and inconsistencies. Grad. Asst.

2. Prepare sample outputs from available meteorological data. Grad. Asst.

3. Catalog major weather stations where data is available for use in the program. Staff

B. Beyond the Grant.

Results from the program were used at the International Soil Correlation Trip in Brazil in 1977. The request for additional information or printouts of moisture regimes indicates a desire by scientific workers to have such information. Outputs could be requested through various AID administrative units.

II. Staff to be Involved

A. Armand Van Wambeke, Professor of Soil Science
B. Technical specialists hired for specific tasks.

III. Scheduled Events/Targets

A. 6 Month Ext (year three)

1. General availability of program to provide assistance as requested. First quarter.

2. Sample outputs for distribution and use. First and second quarters.

3. Locations of weather stations whose data is being used in current efforts.

B. Beyond the Grant.

As additional research is undertaken on soil management systems it will be desirable to know where other areas of the tropics (or world) have similar soil temperature and moisture regimes. This program can provide reasonable estimates quickly depending on the availability of weather information.

IV. Expected Results - 6 Month Ext (year three)

A. 6 Month Ext (year three)

1. A working computer program that estimates soil temperature and soil moisture regimes from meteorological data.

2. Sample outputs reviewed by other scientists. For example, at the International Soil Correlation Trip in Southeast Asia in Aug-Sept 1978.

3. Location maps of weather stations whose data has been, or will be stored.

V. Estimated Costs

	6 Month Ext
Salaries & Benefits	$4,500
Travel	-
Supplies	500
Publications	
Other	150
	$5,150

VI. Summary of Results Expected from Estimation of Soil Temperature and Moisture Regimes.

The program currently used is a modification of the USDA-SCS scheme developed by Frank Newhall. A similar program is also used at Ghent, Belgium so that rapid response can be provided to potential users throughout the world. As the information is run and compiled it should greatly assist in developing agro-climatic zone maps which will then be related back to soils of the areas. One of the major problems of adapting Soil Taxonomy in wet-dry tropics is the lack of refinement of moisture regimes as they relate to cropping system. It is hoped that this data will help pinpoint the problem areas.

V. Distribution of Publication

We recommend that AID publish the volumes of Soil Resource Bibliographies in the same format as Volumes I and II and handle major distribution. Cornell and other CST Members are willing to provide a list of individuals and organizations who likely would benefit from the information.

OBJECTIVE/OUTPUT 2. UTILIZING ADVISORY CAPACITY (Concerning Land Assessment and Soil Survey Operations)

Relevance to Grant Purpose

Personal interaction with AID missions and LDC organizations conducting soil research and soil surveys provide the opportunities to share experiences and concerns about soil resource inventories and their evaluation. It is important for us to understand organizational structuring and agency relationships if guidelines and methodology are to be relevant to a wide variety of conditions.

Visits by other scientists acquainted or involved in LDC resource inventories also contribute to the task of developing meaningful procedures that can readily be applied.

Participating in the Poster Sessions of ASA utilizes information developed by the Soil Resource Inventory group.

I. Activities or work to be Performed

A. 6 Month Ext (year three)

1. Participate in workshop on Operational Implications of Bench Soil Agrotechnology Transfer at ICRISAT. Arnold, second quarter.

2. Participate in ASA session illustrating concepts and procedures developed by SRI group. Staff.

3. Bring several specialists to campus to consult with us on methods of evaluation and/or contraints related to survey strategies. Short visits of 1 week or less.

4. Provide for unscheduled short-term technical advising requested and/or approved by AID. Such service for situations not covered or directly related to specified grant activities.

II. Staff Involved

A. Armand Van Wambeke, Professor of Soil Science
B. Richard Arnold, Professor of Soil Science
C. Gerald Olson, Associate Professor of Soil Science
D. Terence Forbes, Research Associate

III. Scheduled Events and Targets

A. 6 Month Ext (year three)

1. Arnold to participate in Workshop at ICRISAT in October.

2. Arnold, Forbes, and Van Wambeke to participate in ASA meetings in Chicago in December.

3. Several visiting scientists for short periods.

IV. Expected Results

1. Assist AID in evaluating implications of Benchmark Soil Projects.

2. Promote use and testing of guidelines developed for evaluating soil resource inventories.

3. Assist AID with unscheduled advisory capacity if possible.

4. Increased understanding of problem areas of the grant as viewed by others.

V. Estimated Costs.

	6 Month Ext
Salaries & Benefits	8,500
Travel	3,000
Supplies	-
Publications	-
Other	500
	$12,000

VI. Summary of Results Expected

The guidelines developed for evaluating soil resource inventories need much testing and a poster session depicting concepts and methods is intended to create awareness and desire to test the approach. The poster idea can be used to explain to other people what our group has done. We have always tried to respond positively to scheduled and unscheduled assistance to AID. Both likely will occur during the extension period.

OBJECTIVE/OUTPUT 3. Education and Improved Training Capacity

Relevance to Grant Purpose

Matching land suitabilities and capabilities to project development plans should have a favorable effect on the ability of small farmers to respond to their environment. Developing meaningful strategies for improved soil resource inventories and appraisals requires increased understanding and communication between pedologists and land use planners. A problem often occurs when soil resource specialists are not involved at any early phase in planning at regional and national levels. In many instances the pedologists have not been fully aware of the information needed to complement the planning process, nor have the planners been aware of the constraints and requirements to provide information they believe to be valuable for their purposes. In an attempt to begin to bridge this gap of communication, understanding and interaction we developed and tested a special program to assist soil survey personnel in LDCs in improving their capability in (1) understanding soil resource inventories and appraisals, and (2) providing interpretation of soils information designed to meet the special needs of land use planners and decision makers. The major objective was to develop and test a program to enable middle management soil scientists to interact effectively with planning personnel.

I. Activities or Work to be Performed.

A. 6 MO EXT (year three)

1. Continue to assemble materials used at the Philippine Training course. It appears now that a complete set of training materials cannot be prepared. Staff.

2. Assist in trial evaluation of guidelines by graduate student. Arnold and Olson.

II. Staff to be Involved

A. Armand Van Wambeke, Professor of Soil Science
B. Richard Arnold, Professor of Soil Science
C. Gerald Olson, Associate Professor of Soil Science
D. Terence Forbes, Research Associate

III. Scheduled Events/targets

A. 6 MO EXT (year three)

1. Redevelop training material from existing information of the Philippine course. Many lectures are impossible to recapture. First and second quarters.

2. Provide guidance to student trying out some of the proposed guidelines for evaluating SRI.

IV. Expected Results

1. Collection of available material used or developed for Philippine Training Course. Complete set of material now impossible to develop without major expense and effort.

2. Input into thesis involving SRI methods.

V. Estimated Costs

	6 Mo Extension
Salaries & Benefits	$3,000
Travel	-
Supplies	
Publications	500
Other	250
	$3,750

VI. Summary of Expected Results

It has not been possible to put together the pieces of the Philippine Training Course because of conflicting priorities and lack of lecture material presented by some lectures. Some of the material has been incorporated in the Guidelines of the SRI Group. A professional paper employing many of the guidelines will be available during the first quarter. It will demonstrate how the procedures might be used.

OBJECTIVE/OUTPUT 4. LINKAGES AND COLLABORATION

Relevance to Grant Purpose

In order to utilize existing competency on one hand, and to increase the capacity to respond on the other, it is important to maintain and strengthen linkages established through the previous 211(d) grant period. We plan to maintain contacts with agencies, institutions, and individuals who are interested in understanding and utilizing the knowledge and skills related to this grant.

It is desired to collaborate as much as possible with CST members in their activities as well as participate in executive meetings. To facilitate communication between the project and Bureaus of AID, it is proposed to have senior staff spend some time in Washington explaining and discussing aspects of the soil resource and BNF subject areas.

I. Activities or Work to be Performed

A. 6 MO EXT (year three)

1. Attend scheduled meetings with other CST members including executive meetings. Van Wambeke.

2. Handle CST Newsletter. Staff.

3. Prepare end of year-two summary, for 6-month extension, and final report. Staff.

4. Paricipate in International Soil Correlation Workshop in Malaysia and Thailand organized by Puerto Rico. Van Wambeke and Arnold.

5. Confer with appropriate AID personnel in Washington. Senior staff.

6. Assist in preparation of workshop on Program Priorities for Alleviating Soil Related Constraints to Food Production.

II. Staff Involved

A. Armand Van Wambeke, Professor of Soil Science
B. Richard Arnold, Professor of Soil Science
C. Gerald Olson, Associate Professor of Soil Science
D. Terence Forbes, Research Associate

III. Scheduled Events/Targets

1. Executive meeting of CST. Likely in November.

2. CST Newsletter. As regularly scheduled.

3. Reports as required. First and second quarters.

4. Soil Correlation Workshop. August-September. Preparation of Workshop program.

IV. Expected Results

A. Continued collaboration with associates in CST, at International Centers, LDC institutions, and elsewhere.

B. Maintaining linkages and contacts, especially in LDCs.

C. Extension of information produced as outputs as well as continued international linkages.

D. Improved understanding by AID and Cornell of activities and constraints.

V. Estimated Costs

	6 Month Ext
Salaries & Benefits	$6,000
Travel	1,000
Supplies	-
Publications	-
Other	550
	$7,550

VI. Summary of Results Expected from Developing Linkages and Collaboration

Coordination of activities and assisting CST members are basic to the continuation of these grant activities. Because staff of the CST institutions will be devoting major time to their specific areas of concern there will be less time for collaborative work, yet interaction and cooperation will be maintained consistent with other duties of staff members. This helps to keep our horizons open.

Part of this output is the opportunity to better comprehend the structure, needs, and policies of AID and relationships with universities for mutual understanding of long range goals. This additional understanding by AID and Cornell should benefit both institutions.

Listed below are the estimated work-months of effort projected during a 6-month extension to complete the Plan of Work outlined under the objectives in the Soil Resources component:

Objective I. Broadened Knowledge Base

A. Evaluation of Soil Resource Inventories

	6 Month Extension
Senior Scientists	0.5
Research Support Spec	7.5
Graduate Research Asst	12.0
Technical Specialists	5.0
Visiting Scientists	1.0
	26.0

B. Strategy for Increasing Effectiveness of Soil Surveys

Senior Scientists	0.5
Research Support Spec	3.0
Graduate Research Asst	12.0
Technical Specialist	2.0
Visiting Scientists	2.0
	19.5

C. Estimation of Soil Temperature and Moisture Regimes.

Senior Scientists	0.5
Graduate Research Asst	3.0
	3.5

Objective II. Building & Utilizing Advisory Capacity

Senior Scientists	1.5
Research Support Spec	.5
Graduate Research Asst	-
Technical Specialist	.5
Visiting Scientists	1.0
Other Cornell Scientists	1.0
	4.5

Objective III. Education & Improved Training Capacity

	6 Month Extension
Senior Scientists	0.5
Research Support Spec	-
Graduate Research Asst	-
Technical Specialist	0.5
Visiting Scientists	-
	1.0

Objective IV. Linkages & Collaboration

Senior Scientists	0.8
Research Support Spec	1.0
Graduate Research Asst	-
Technical Specialist	1.0
Visiting Scientists	-
	2.8

In support of the previously listed objectives, additional work-months are provided by secretarial staff and administrative aide, both one-half time on the grant.

10. Involvement of Minority Personnel and Women

Cornell has employed the following personnel under the 211(d) grant during this reporting period. Their positions - country of origin are also listed:

Milegua Layese-Bloom	Philippines	Graduate Assistant
Pamela Piech	U.S.A	Graduate Assistant
Kingston Nyamapfene	Rhodesia	Graduate Assistant
Hari Eswaran	Malaysia	Visiting Scientist
Ann Whynman	U.S.A.	Res Support Specialist
Connie Quenette	U.S.A.	Secretary
Merrily Dethier	U.S.A.	Administrative Aide
Sheila Ferrari	U.S.A.	Editorial Assistant
Nancy Lange	U.S.A.	Res Support Specialist

Soil Resources Component

Table I. Distribution of 211(d) Grant Funds and Contributions from Other Sources of Funding

Reporting Period July 1, 1977 to June 30, 1978

Grant Objectives/Outputs	211(d) Expenditures			Non-211(d) Funding * Amount
	Period Under Review	Cumulative Total	Projected 6-Month Extension	
I. Broadened Knowledge Base				
a. Evaluation of Soil Resources	$51,103.99	$96,581.66	$26,095.00	$33,759.00
b. Strategy for Increasing Effectiveness of Soil Surveys	16,154.58	20,504.58	24,710.00	10,482.00
c. Bibliography of Soils in the Tropics (and, Soil Temperature & Moisture Regimes)	5,200.00	7,900.00	5,150.00	0.00
II. Building & Utilizing Advisory Capacity	10,298.77	21,465.20	12,000.00	6,310.00
III. Education & Improving Training Capacity	10,496.26	30,283.90	3,750.00	3,783.00
IV. Linkages & Collaboration	35,340.91	43,947.67	7,550.00	15,722.00
TOTAL	$128,594.51	$220,683.01	$79,255.00	$70,056.00

(*University contribution for overhead, fringe benefits, tuition)

Soil Resources Component

Table II - A. 211(d) Expenditure Report, Actual and Projected Summary Under Institutional Supplemental Grant AID/csd 2834

Reporting Period July 1, 1977 to June 30, 1978

Expenditure Category	Reporting Period	Cumulative Total	Projected Expenditures 6-Month Extension	TOTAL
Salaries & Benefits	$83,207.13	$133,168.85	$59,000.00	$192,168.85
Consulting & Honorariums	5,340.00	12,374.28	0	12,374.28
Travel & Per Diem	17,159.24	38,721.75	14,928.00	53,649.75
Supplies & Equipment	5,867.58	10,693.65	1,810.00	12,503.65
Publications	4,716.68	8,213.26	1,955.00	10,168.26
Other Direct Costs	12,303.88	17,511.22	1,562.00	19,073.22
TOTAL	$128,594.51	$220,683.01	$79,255.00	$299,938.01

Soil Resources Component

Table II-B. 211(d) Expenditure Report Reporting Year Detail Under Institutional Grant AID/csd 2834

Reporting Period July 1, 1977 to June 30, 1978

I.	A. Salaries - Professional		
	R. Arnold	20%	$ 4,813.98
	A. Van Wambeke	25%	7,470.25
	T. Forbes	100%	14,690.13
	M. Laker	50%	883.48
	H. Eswaran	100%	10,620.04
	A. Stobbs	100%	7,594.48
	C. Scoppa	100%	900.00
	B. Salaries - Other		
	A. Whynman	100%	6,707.62
	M. Dethier	50%	5,550.27
	C. Quenette	50%	4,887.14
	S. Ferrari	50%	1,080.98
	G. Thomasson	50%	5,519.32
	N. Lange	100%	3,101.25
	C. Fringe Benefits - No Charge to Grant		
II.	Student Support		
	C. Lau	(U.S.A.)	1,526.10
	M. Layese-Bloom	(Philippines)	865.19
	K. Nyamapfene	(Rhodesia)	1,248.00
	P. Piech	(U.S.A.)	1,933.46
	E. Bui	(U.S.A.)	3,387.94
	M. Schwartz	(U.S.A.)	427.50
III.	Consultants		
	A. Orvedal, Bibliographies		5,200.00
	Dr. Eswaran, Honorarium		140.00
IV.	Travel - Domestic	21 trips	5,809.13
	Foreign	13 trips	11,350.11
V.	Equipment - Decwriter		2,713.00
VI.	Library Acquisitions		416.68
VII.	Publications		4,300.00
VIII.	Other: Communications, postage, supplies, fees, computer, soil analyses, agreements		15,458.46
			$128,594.51

SOIL RESOURCE COMPONENT

Table III-A. Requests for Assistance Received During Reporting Period July 1, 1977-June 30, 1978

A. Requests Attended

Description of Request for Assistance	Whom did you Assist?	Who Requested Assistance	Who Funded Assistance	Size of Effort Dollars/Days	Results of Assistance
1. To advise on setting up soil data bank & selection of data for soil correlation, soil survey interpretation, land evaluation & management in Argentina.	INTA/FAO	INTA/FAO	FAO	Air fare & Per diem /1 Month	Computerized soil moisture regime & soil correlation program for INTA & Univ of Buenos Aires
2. Participate in Seminar on Improved Farm Producation Systems, Republic of Mali.	USAID Rep of Mali	USAID	USAID	Air fare & per diem /5	Assist development proj. design for Rep. of Gambia & Cape Verde Islands
3. Assist USAID in writing Proposal for Yemen Arab Republic for agricultural assessment	USAID Near East Bureau	USAID Near East Bureau	Cornell 211d Grant	$873.64/10	Restructured Budget and schedule of operations for proposal
4. Evaluation of CRIES	USAID	USAID	Cornell 211d Grant	$604.00/9	Evaluated natural resource inventory in Central America
5. Soil Survey Assistance in Haiti	USAID Haiti	Initiated by Cornell Univ.	Cornell 211d Grant	$1232.00/18	Determined feasibility of soil resource inventory evaluation
6. Advise Soil Sci. Dept., Univ West Indies on feasibility of micromorphological research and soil survey in the Caribbean region.	Univ of West Indies	Univ of West Indies	Cornell 211d Grant	$686.00/9	Made recommendations for laboratory studies based on evaluation

SOIL RESOURCE COMPONENT

Table III-B. Requests for Assistance Received During Reporting Period July 1, 1977-June 30, 1978

B. Requests Not Fulfilled

Description of Request for Assistance	Whom did you Assist?	Who Requested Assistance	Who Funded Assistance	Size of Effort Dollars/Days	Results of Assistance
1. Assist in Republic of Djibouti Agricultural Sector and Manpower Development Study	USAID/Wash	USAID/Wash	USAID/Wash		Postponed until mid-July 1978. To be reported during next report period.
2. Request for soil sampling and analysis to assist Land Development Dept. Bangkok, Thailand	Dept. Land Development Bangkok	Dept. Land Development Bangkok	Cornell's 211d Grant		To be conducted early Aug 1978 and reported during next report period.

A. Title II. Biological Nitrogen Fixation Component of 211(d) Supplemental Grant AID/csd 2834

Biological Nitrogen Fixation Director:

Dr. M. Alexander

Statistical Summary:

Amount of Grant Allocated:	$150,000.00
Accumulated Expenses:	$115,091.77
Anticipated Expenses:	$ 34,900.00

Reporting Period: July 1, 1977 - June 30, 1978

B. NARRATIVE SUMMARY

HIGHLIGHTS OF ACCOMPLISHMENTS - BIOLOGICAL NITROGEN FIXATION

After discussions between Cornell University personnel and representatives of the grain legume program at the University of the West Indies in Trinidad, several experiments were set up to look into the effects of and limitations on Biological Nitrogen Fixation in Trinidad soils.

One experiment tested the addition of lime and phosphorus on the yield of black-eyed peas (Vigna unquiculate) planted on an Ultisol (Piarzo Fine Sand), a highly acid soil almost devoid of all plant nutrients. Examination of the results indicated that there was no significant difference in grain yields between plots that received no lime and plots that received 4 metric tons of lime per hectare. However, the addition of 20 kg phosphorus per hectare more than doubled the grain yield while more phosphorus gave no further increase. There was no interaction between lime and phosphorus.

A second experiment compared the effects of fertilizer nitrogen and Rhizobium inoculation on grain yields of soybean (Glycine max) and black-eyed peas sown on the same Ultisol (Piarzo Fine Sand). The black-eyed peas yielded slightly higher inoculated with a rhizobial strain originally isolated from Piarzo Fine Sand then if inoculated with a strain from a Trinidad clay or if uninoculated. The uninoculated soybeans apparently picked up an indigenous strain and gave higher yields than soybeans inoculated with either of two commercially-used strains. In both soybeans and black-eyed peas 60 kg N/ha as urea gave higher yields with all Rhizobium treatments than no nitrogen, while 120 kg N/ha gave no further improvement. No significant interaction between inoculation and nitrogen fertilization was found.

Followup experiments tested the residual effects of the Rhizobium-nitrogen fertilizer trials. Inoculated or uninoculated soybeans were replanted on the previous soybean beds. Results indicated no residual effect of nitrogen fertilizer, while sufficient Rhizobium remeshed in the soil so that no significant differences were found in yields of inoculated or uninoculated plots. The results of a test for residual effects of the cowpeas on yields of sorghum are still being analyzed.

A third set of experiments on a moderately acid, fertile soil (Niber Estate Loam) determined the response of corn to residual and/or fertilizer nitrogen. Following fallow, corn or cowpea crops in the major season, corn was grown in the minor season fertilized with 0, 30, 60, or 120 kg N/ha as urea. The results for this corn crop show that yields are influenced by the previous crop in the sequence - cowpeas - fallow - corn - and that in each case yields increased in parallel with fertilizer nitrogen.

Details for these experiments, discussion of the results and proposed research are included in an appendix to this report.

C. Detailed Report

1. General Background and Description of Problem.

A major contraint in the improvement of agricultural production in developing countries is the low natural fertility of extensive unutilized and under-utilized soils of the tropics. Most farmers are unable to buy much fertilizer, if any, and the greatly increased fertilizer cost in the last two years has greatly worsened the situation. On most soils it is necessary to augment the natural supply of nitrogen in order to get any substantial increase in crop production. Because of the high cost of nitrogen fertilizer, other ways of supplying nitrogen need to be found. A November 1975 report of the Board on Agriculture and Renewable Resources of the National Academy of Sciences states "There is real need to develop and install soil management practices involving alternatives to inorganic sources of nitrogen, such as legumes in crop sequences or as cover crops and organic sources such as animal and human wastes. This is a high priority problem."

Biological nitrogen fixation provides an important way to supply substantial amounts of nitrogen for increased crop production. It constitutes an important component for evaluation of soil resource potential for crop production in tropical areas especially where low income farmers have no access to nitrogen fertilizers. A survey by a task force convened by the United Nations Environment Program secretariat indicated that, despite the enormous need for fertilizer nitrogen in the tropics and the capacity of the legume-*Rhizobium* symbiosis to make use of otherwise unavailable molecular nitrogen, almost no research was being done in the LDCs and there were few technically trained personnel in the tropics able to initiate or carry out an activity designed to help exploit the nitrogen fixing capacity of the *Rhizobium*-legume symbiosis.

The use of biological nitrogen fixation is of special value to the small farmer. Labor intensive mixed cropping systems can be used with legume supplying some nitrogen for the production of associated crops as well as for their own needs. Some soils contain rhizobia for adequate nodulation of the legumes so they can fix nitrogen, but other soils either lack rhizobia or the strains present are ineffective. Special attention needs to be given to development and utilization of technology related to biological nitrogen fixation.

2. Purpose of the Grant.

The purpose of the 211(d) Supplemental Grant, BNF Component is to strengthen the institutional response capability in biological nitrogen fixation in tropical environments. This purpose is being achieved by:

a. Evaluating nitrogen fixation by various microorganisms in crop production under different environmental conditions, and

b. Evaluating soil and climatic conditions and constraints affecting biological nitrogen fixation and utilization of fixed nitrogen.

The purpose is primarily directed to development of a greater response capability in the area of biological nitrogen fixation for developing countries, especially in the tropics, where knowledge and expertise are very limited. While enhancing this capability, it is anticipated that it will be utilized during the grant period.

3. Major Objectives/Outputs Restated

The objectives of the 211(d) grant, BNF Component are considered under five types of outputs: 1) broadend knowledge base, 2) building and utilizing advisory capacity, 3) education and improved training capacity, 4) increased research capability, and 5) linkages and collaboration.

a. Broadend Knowledge Base

1. Aspects of Biological Nitrogen Fixation.

Cornell has major responsibility to prepare review documents on the following subjects: (1) factors affecting the survival of Rhizobium as related to BNF, (2) soil and plant gains of nitrogen from BNF, (3) biological nitrogen fixation associated with lowland rice, and (4) cross-inoculation groups with major emphasis on tropical plants. Cornell will assist CST members with documents on soil properties affecting biological nitrogen fixation and utilization of fixed nitrogen.

The staff will provide assistance to other CST institutions who have primary responsibility for related subjects, mainly Hawaii, North Carolina, and the University of Puerto Rico. Attendance at Hawaii BNF workshop and a site visit to Brazil will enable us to increase our ability to assist others in BNF Programs.

b. Building and Utilizing Advisory Capacity

Two or more site visits are planned to learn firsthand about BNF work. Several scientists familiar with tropical conditions will visit the campus to consult with Cornell staff on evaluation of microorganisms for N fixation in crop production to develop a better understanding of environmental contraints affecting BNF and N use.

c. Education and Improving Training Capacity

Another objective is improve the training capacity of staff in BNF by developing and conducting an intern program for LDC specialists. This will enable us to be more familiar with their academic and skill needs and plan meaningful training for them. See "Accomplishments".

d. Increased Research Capability through Improved Competence in Guiding and Conducting Relevant BNF Research

This competence is especially needed so that microbiologists become familiar with soil fertility problems and soil fertility specialists become directly acquainted with microbiology problems. The laboratory and field

studies being conducted both in Ithaca and Trinidad with the University of the West Indies will permit the design and testing of experiments on BNF under tropical conditions. The research will focus on assessment of BNF in the field, especially on nitrogen gains in tropical soils, and on strain selection with particular emphasis on survival of rhizobia in tropical soils. These activities serve to provide in-service training of staff through research.

e. Linkages and Collaboration

Continued collaboration and cooperation with CST members will be through executive meetings each year, participating in joint workshops, and assisting in state-of-the-art studies.

Short visits will be made to BNF centers to discuss projects of mutual concern. Invited specialists will help orient staff activities to better respond to requests for technical assistance.

Short visits to learn and share viewpoints with AID/Washington regional and technical assistance personnel should benefit the grantee and sponsor and lead to increasing utilization of the capacities and capabilities of all concerned.

In the BNF area, collaboration is also anticipated with IRRI on nitrogen fixation in rice production and with the UNEP-supported *Rhizobium* center in either Brazil or Kenya and with additional UN-supported BNF programs in the tropics.

4. Critical Assumptions

To achieve the purposes of this grant, the following are assumptions beyond the control of Cornell:

a. AID and other donors will assist in generating requests for utilization of the added knowledge and strengthened response capabilities in biological nitrogen fixation,

b. There is a clientele of interested and qualified personnel from LDCs for proposed research and training programs in biological nitrogen fixation,

c. The other CST institutions will collaborate in the joint activities proposed for biological nitrogen fixation, and

d. Cornell University with AID and other technical assistance agencies' support will work jointly to develop and implement follow-up activities to improve research, training, and agronomic implementation of biological nitrogen fixation.

5. Accomplishments

a. Broadend Knowledge Base

1. Aspects of Biological Nitrogen Fixation.

Two States-of-the-Art (SOTAs) have been essentially completed, one is nearly completed and the fourth is to be initiated shortly. The two that are essentially complete deal with (a) the survival of *Rhizobium* in

soil and (b) soil N and plant N gains from biological nitrogen fixation. All of the necessary data have been collected for the writing of the SOTA dealing with cross-inoculation groups of legumes, with particular reference to tropical species.

The extensive reading, evaluations and discussions necessary for the preparation of these documents led to the Cornell faculty becoming familiar with the published literature in this area and to a series of fruitful discussions and interchanges of ideas. As a result, the faculty members at Cornell University have aquired considerable depth/breadth in problems of BNF in tropical soils and the biological and agricultural factors associated with legume production in the LDCs.

b. Building and Utilizing Advisory Capacity

Site visits have been conducted by faculty members to review on-going BNF in Caribbean islands, France, New Zealand and the Philippines. Future visits will bring Cornell faculty members in contact with programs in Latin America and in Southeast Asia. Staff scientists from institutions in the Philippines, Argentina, Trinidad, Nigeria and Canada have visited or shortly will be visiting the Cornell campus, and additional visits are expected in the next year of the grant. Some of the scientists have given lectures to graduate students, postdoctorals and faculty members in the Department of Agronomy concerned with BNF as well as other programs. Faculty members have participated in planning activities for the UN-BNF Program.

Dr. M. Alexander has been in Kenya to meet with the staff of the UN Environmental Program (UNEP secretariat and in France to meet with the coordinators of the FAO and UNESCO Programs on BNF. In addition, he has served as advisor to the UN in establishing two *Rhizobium* Microbiological Resource Centers (MIRCENs).

c. Education and Improving Training Capacity

As part of the objective to improve education and training capacity of Cornell staff, four postdoctoral scientists (3 from LDCs) have been involved directly with the AID supported program. One graduate student is also supported by the activity. Furthermore, the program in the Department of Agronomy has been expanded to include other facets of BNF (with other than AID funds) and one postdoctoral and six graduates students are thus also participating in the BNF program; of these individuals, the postdoctoral and three of the graduate students came from LDCs.

The training activity has involved field research in the Caribbean, greenhouse studies and laboratory investigations, and many aspects of symbiotic/non-symbiotic nitrogen fixation by legumes, microbial-grass associations, and free-living microorganisms have been included. Hence, the capacity of the Cornell staff to train individuals from the LDCs has increased markedly, even in the past year.

d. Increased Research Capability through Improved Competence in Guiding and Conducting Relevant BNF Research

In support of this output, activities have followed several different directions. The approaches have been defined on the basis of the requirements for practical information and, at the same time, the need to increase the capability of the Cornell staff to conduct and supervise research relevant to problems in tropical regions. The work in the field, greenhouse and laboratory has involved agronomic field techniques, soil analyses, microbiological procedures, plant growth experiments under controlled conditions and assays for BNF by the acetylene-reduction technique. The investigations are focusing on evaluations of responses to inoculation, factors affecting the survival of root-nodule bacteria in soil, attempts to promote colonization of active nitrogen-fixing bacteria on legumes and non-legumes, and means to promote increased BNF by free-living bacteria and algae in lowland rice production.

Experimental sites have been acquired in Trinidad on a highly weathered, acid soil, and cowpeas and soybeans were seeded at these locations. A second experiment was established at the University of West Indies involving cowpeas and maize. Labeled strains (antibiotic-resistant mutants) of cowpea and bean Rhizobium were obtained, and these have been used for learning methods of evaluating survival of the root-nodule bacteria in soil. Soil stresses, particularly acidity, were also evaluated using the Rhizobium that is able to fix nitrogen in association with beans. The studies showed some of the difficulties in evaluating survival of the bacteria in soil and demonstrated the rapid decline of the organisms under acid conditions. Studies are also under way to devise means to make bean and cowpea Rhizobium more competitive under field conditions, and these investigations are bringing Cornell staff into contact with additional problems of handling the microorganisms, developing new types of strains, and evaluating these strains and their competitive ability on plants in greenhouse conditions.

e. Linkages and Contracts

Developing linkages and cooperation, another output, has also been the center of attention. Close collaboration has been developed with IRRI, the Boyce Thompson Institute for Plant Research and University of the West Indies. It is anticipated that the linkages and collaboration will be extended and expanded in future years, in part because of the existence of a UN Development Program (UNDP)-supported research activity of BNF (involving Cornell, Boyce Thompson Institute and IRRI) and in part because of the move of the Boyce Thompson Institute to the Cornell campus. Linkages have also been developed with the French BNF programs in West Africa, and contacts have been made with French scientists in Dijon and Montpellier in support of possible future activities. As chairman of the UN Nitrogen Fixation Advisory Committee, Dr. Alexander has developed useful contacts through FAO, UNESCO, and UNEP secretariats and, as part of the UNEP activity, has worked closely with the Rhizobium Microbiological Resource Center (MIRCEN) that has just been established in Nairobi, Kenya. In addition, an on-going program in Ghana as well as contacts that are being developed with IITA should lead to fruitful collaboration in West Africa.

As one of the four institutions cooperating in the BNF program of the Consortium on Soils of the Tropics, Cornell staff have participated directly in joint planning activities and discussions with the other institutions (North Carolina State University, University of Hawaii and University of Puerto Rico). It is expected that the work done in line with the present proposal will further develop these linkages and collaborative activities.

6. Impact of Grant Supported Activities in Achieving Grant Purpose.

The preparation of SOTAs has brought the Cornell faculty in direct contact with needs and problems in tropical BNF and has increased their knowledge base. Contacts and requests that have been generated during the grant period have greatly improved Cornell's capacity to respond to future requests on BNF. The training activities of the past year, moreover, have permitted us to expand our means of guiding graduate students and young scientists from the LDCs in BNF, and there has been a growing awareness of Cornell as a center for such work. Furthermore, the faculty members in soil fertility have become more familiar with the microbiological aspects of BNF, and the faculty microbiologist has been actively involved with increasing his competency in field research. In addition, existing linkages and collaborative activities have been markedly strengthened and new linkages and areas of collaboration have been initiated.

7. Other Resources for Grant Related Activities

The financial plan indicates the amount of other funding that relates to satisfying the 211(d) grant purposes. The University commitment includes the salary of the State-supported professor, and about three work months advising and consulting services of other senior staff. Costs associated with these salaries include fringe benefits and overhead. Fringe benefits and overhead are also provided for those salaries supported by the grant. A small amount for library acquistions and costs of publishing articles related to the grant purpose are also included.

Important sources of outside funding are stipends awarded students from LDCs and other countries whose academic programs are directly related to the grant purposes. At present there are students supported by UNDP, Mexican Government, Nigerian Government and others on Rockefeller or other fellowships, or supported by Hatch funds. We assume that such outside funding will continue at the same level in the future. Additional support is also received from Trinidad, and the University of the West Indies which provides laboratory and field space for the Cornell personnel associated with the cooperative BNF work being carried out there.

8. Utilization of Institutional Response Capabilities in Development Programs.

Faculty members involved with the BNF work at Cornell have made site visits to review on-going BNF in the Caribbean Islands, France and the Philippines. Future visits are planned that will bring them into contact with programs in Latin America and Southeast Asia. In addition to the senior staff members increasing their response capabilities, Dr. Alexander has already participated in the planning activities for the United Nations BNF Program. In this regard, he has been in Kenya to meet with the staff of the UN Environmental Program (UNEP) secretariat and in France to meet with the coordinators of the FAO & UNESCO programs on BNF. Dr. Alexander also served as advisor to the UN in establishing two Rhizobium Microbiological Resource Centers (MIRCENs).

Graduate students in the Department of Agronomy represent many different countries. Among those working with the BNF project, either directly or indirectly, one student is from Nigeria, one from Costa Rica, and one being supported in his work by the Mexican government. Four American students are also working in BNF and are supported by funds other than 211(d). In addition, Dr. M. Habte from Ethiopia is working on BNF associated with rice production on a project supported by UNDP and involving the Boyce Thompson Institute and IRRI; and three other postdoctorals have been involved with the work this year, Dr. Spider Mughogho, Dr. Henry Lowendorf, Dr. Ana Marie Baya, and Dr. V. Odunfa. The capacity of the Cornell staff to train individuals has increased during this reporting period.

9. Six-Months Extension Plan of Work and Anticipated Expenditures.

All four of the SOTA documents will be completed. This entails the final stages of the SOTA on survival of Rhizobium on soil nitrogen and plant nitrogen gains from BNF. The data collected for the SOTA on cross inoculation of legumes will be integrated and the document prepared. The reviewing of literature on BNF in association with rice will be completed, a first draft of the SOTA will be prepared, and this draft and assessment of the field and its problems will be completed. The various SOTA documents will be discussed and evaluated both by the Cornell staff and by the scientists from other institutions.

Additional site visits and discussions with BNF researchers at other locations will be conducted. These visits and discussions will be designed to fill in the major knowledge gaps of the Cornell faculty. BNF specialists from other countries will visit the Cornell campus, and some will present lectures to Cornell faculty members, postdoctorals and graduate students. Continuing emphasis will be placed on improving our capacity for training and education of LDC personnel in BNF, and one graduate trainee will be involved in the program in the next 6 months. Research in the field in the Caribbean in connection with the University of West Indies, in the greenhouse and in the laboratory will be continued to further develop our knowledge of approaches and problems in studying BNF, with particular reference to nitrogen gains and survival of Rhizobium. Additional linkages and collaborative activities will be developed with scientists at IITA, Boyce Thompson Institute, IRRI, personnel involved with the MIRCENs in Kenya and Brazil, and scientists concerned with BNF in Southeast Asia.

This work plan is consistent with the original proposal funded by AID.

10. Involvement of Minority Personnel and Women

Cornell has employed the following personnel to work under the 211(d) grant during this reporting period. Their positions - country of origin are also listed

S. Mughogho	Malawi	Research Associate
A.M. Baya	Chile	Postdoctoral Fellow
V. Odunfa	Nigeria	Postdoctoral Fellow
S. Hunt	U.S.A.	Stenographer
C. Quenette	U.S.A.	Secretary
D. Marshall	U.S.A.	Secretary
M. Dethier	U.S.A.	Administrative Aide
J. Pena-Cabriales	Mexico	Graduate Research Assistant

Biological Nitrogen Fixation Component

Table I. Distribution of 211(d) Grant Funds and Contributions from Other Sources of Funding

Reporting Period July 1, 1977 to June 30, 1978

Grant Objectives/Outputs	211(d) Expenditures			Non-211(d) Funding * Amount
	Period Under Review	Cumulative Total	Projected 6-Month Extension	
I. Broadened Knowledge Base				
a. Biological Nitrogen Fixation	$23,847.27	$41,616.02	$ 7,162.00	$11,804.00
II. Building & Utilizing Advisory Capacity	1,781.95	6,347.96	7,918.00	1,185.00
III. Education & Improving Training Capacity	10,570.78	20,073.28	11,929.00	1,795.00
IV. Increase Research Capability Through Improved Competence in Guiding & Conducting Relevant BNF Research	24,605.48	42,283.51	5,895.00	11,599.35
V. Linkages & Contacts	3,004.21	4,771.00	1,996.00	763.00
TOTAL	$63,809.69	$115,091.77	$34,900.00	$25,369.35

(* Overhead, fringe benefits, tuition, University contribution)

Biological Nitrogen Fixation Component

Table II-A. 211(d) Expenditures Report, Actual and Projected Summary Under Institutional Supplemental Grant AID/csd 2834

Reporting Period July 1, 1977 to June 30, 1978

Expenditure Category	Reporting Period	Cumulative Total	Projected Expenditures 6-Month Extension	TOTAL
Salaries & Benefits	$45,648.91	$86,784.45	$21,000.00	$107,784.45
Consulting or Honoraria	50.00	50.00	0.00	50.00
Travel & Per Diem	8,872.17	17,027.24	3,628.00	20,655.24
Supplies & Equipment	970.29	1,802.99	530.00	2,332.99
Publications	1.20	1.20	999.00	1,000.20
Other Direct Costs	2,760.83	3,919.60	1,500.00	5,419.60
Memorandum of Understanding Univ. West Indies	5,506.29	5,506.29	7,243.00	12,749.29
TOTAL	$63,809.69	$115,091.77	$34,900.00	$149,991.77

Biological Nitrogen Fixation Component

Table II-B. 211(d) Expenditure Report Reporting Year Detail
Under Institutional Grant AID/csd 2834

Reporting Period July 1, 1977 to June 30, 1978

I. A. Salaries - Professional		
D. Bouldin	10%	$ 714.46
D. Lathwell	10%	745.92
T. Scott	10%	610.43
H. Lowendorf	100%	17,883.27
S. Mughogho	100%	16,845.30
B. Other Salaries		
A. Baya, Trainee	100%	4,500.00
V. Odunfa, Trainee	100%	1,925.00
S. Hunt, Secretary	5%	363.37
M. Slator	5%	123.00
C. Fringe Benefits - No charge to Grant		
II. Student Support		
J. Pena-Cabriales		1,938.16
III. Consultants/Honoraria		
Dr. Watanabe		50.00
IV. Travel - Domestic	8 trips	2,899.61
Foreign	15 trips	5,972.56
V. Equipment - No purchases of $2500 or more		
VI. Library Acquisitions - No charges		
VII. Publications		1.20
VIII. Other - Communications, postage, supplies		3,731.12
IX. Memorandum of Understanding University of the West Indies		5,506.29
		$ 63,809.69

BNF component

Request for Assistance Received During Reporting Period of 211(d), grant

July 1, 1977 to June 30, 1978

Table III-A.

Requests Attended Description of Request for Assistance	Whom did you assist?	Who requested Assistance?	Who funded Assistance?	Effort Dollars Time (man days)	Results of Assistance
A. Request to visit IRRI in the Philippines, Research center in New Zealand and programs in Bangkok in the areas of research in BNF legume production and *Rhizobium* testing.	Researchers at IRRI and in other countries in S.E. Asia	IRRI and UNEP	IRRI UNEP AID	13	Development of cooperative research and plans for future research
B. Coordination of joint research programs on BNF with IRRI and Boyce Thompson Institutes for Plant Research	IRRI and Boyce Thompson Institute (BTI)	IRRI and BTI	UNEP	3	Conducting cooperative research
C. Served as chairman of Nitrogen Fixation Advisory Committee of the Microbiology Panel of UNEP/UNESCO and advisor on the two international Rhizobium Research Centers sponsored by UNEP.	Rhizobium centers in Kenya and Brazil	UNEP	UNEP	2	Redirection of programs of these centers

A P P E N D I C E S

HIGHLIGHTS

Soil Microbiology Work under 211(d) Program, July 1977-June 1978

H. S. Lowendorf

1. Field work in Trinidad. See progress report by S. K. Mughogho.
2. Laboratory research continued on Rhizobium survival in soil and in culture at acid pH.
3. Several antibiotic-resistant mutants of Rhizobium (cowpea strains) were isolated and characterized regarding efficiency of nitrogen fixation.
4. Attended the 6th American Rhizobium conference in Gainesville, Florida, in August.
5. Visited legume programs in Belize, Jamaica and Antigua during November. The report of this trip has been sent to Drs. Alexander and Van Wambeke at Cornell, and Drs. Malcolm and Frederick at AID.
6. Returned to Cornell, Ithaca, from Trinidad in March, 1978.
7. Sent revisions of SOTA number 1 - Rhizobium Survival in Soil - to members of the BNF consortium for criticism and suggestions in preparation of a final draft.
8. Began work on SOTA number 2 - Nitrogen Fixation in Lowland Rice.

A. M. Baya

1. Carried out research on survival of Rhizobium in acid soils at Cornell.
2. Attended 6th American Rhizobium Conference.
3. Arrived in Trinidad, December, 1977, to participate in field and laboratory experiments for 3 months.
4. Returned to Chile, April, 1978.

S. Odunfa

1. Carried out research on the effects of systematic fungicides on cowpea rhizobia.
2. Returned to Nigeria, October, 1977.

J. J. Pena

1. Carried out research on Rhizobium survival to drought.
2. Finished master's thesis at Cornell, "Survival of Rhizobium in Soil During Drying."

M. Alexander

1. Visits to International Rice Research Institute in the Philippines, University of the West Indies in Trinidad, research centers in New Zealand, and programs in Bangkok in the areas of research on BNF legume production and Rhizobium testing.
2. Coordination of joint research programs on BNF with International Rice Research Institute and Boyce Thompson Institute for Plant Research.
3. Served as chairman of Nitrogen Fixation Advisory Committee of the Microbiology Panel of UNEP/UNESCO and advisor on the two international Rhizobium research centers sponsored by UNEP.

Proposed Work for July, 1978-December, 1978

H. Lowendorf

1. Submit SOTA I - Rhizobium Journal in Soil - to AID.
2. Complete SOTA II - Nitrogen Fixation in Lowland Rice
3. Continue research on Rhizobium survival in acid soils.
4. Attend 9th Latin American Rhizobium meeting in Mexico, October, 1978.

J. J. Pena

Begin research toward Ph.D. degree on the effects of vegetation on the establishment of introduced Rhizobium strains in soil.

M. Alexander

Continuation of activities listed above.
Complete SOTA III - Cross-inoculation groups.

CORNELL/UWI BIOLOGICAL NITROGEN FIXATION PROJECT

ANNUAL REPORT

A) PROJECT TITLE: Maximizing the Grain Yield and Symbiotic Nitrogen Fixation by Grain Legumes in Trinidad.

B) PRINCIPAL INVESTIGATORS: Spider K. Mughogho
Henry S. Lowendorf

C) REPORTING PERIOD: March, 1977 - June, 1978

D) INTRODUCTION:

Production and consumption of fertilizer nitrogen has increased by a factor of about 10 in the last twenty years. It has been predicted that twenty five years from now, 200 x 10^6 metric tons of fertilizer N will be required annually in absence of alternative techniques for producing fixed N. This has generated a greatly expanded interest in the *Rhizobium* - legume based symbiotic N_2 - fixation. These conditions are essential for successful symbiotic N_2 - fixation:

(a) the host plant and the *Rhizobium* must be matched; in other words, the fixation of nitrogen by legumes is governed by the effectiveness of the symbiotic association between a particular legume and a *Rhizobium* strain. Thus the *Rhizobium* strain has to be able to nodulate the legume and subsequently the nodule has to have the ability to fix nitrogen.

(b) the soil and environmental conditions must be suitable for the growth of the host plant. Adding required nutrients or eliminating toxic effects will increase the growth of legumes and thereby the need for N either from the soil or by symbiotic fixation.

(c) the soil and environmental conditions must be favourable for the survival of the *Rhizobium* strain. It is possible to select strains which are tolerant to stress conditions commonly found in the soils of the tropics, e.g. acidity, high temperatures, and long dry spells

E) RESEARCH ACTIVITIES:

After several discussions between Dr. Henry Lowendorf and me on one side and several people at the University of West Indies working on grain legumes on the other side, we decided to set up three field experiments. We were advised to work on soybeans and/or cowpeas (blackeye peas).

1) Maximizing grain yield and biological nitrogen fixation through liming and phosphorus application on an ultisol in Trinidad:

Introduction:

In soils, plant growth is likely to be affected more commonly by factors related to soil acidity such as aluminium and/or manganese toxicity, phosphorus, calcium and/or molybdenum deficiencies. It has been reported in the literature that many tropical legumes are capable of growing in soils that are too acid for a good growth of many temperate legumes. This may be that tropical legumes can tolerate excessive Al and/or Mn, and that they are more efficient in extracting Ca. Excess Al and/or Mn may also depress the *Rhizobium* - host symbiosis. Work in Brazil has revealed that *Glycine* and *Phaseolus* developed nodules and fixed N_2 satisfacotorily at surprisingly low pH levels, provided Mn toxicity is not the limiting factor (Dobereiner, 1966), or Al toxicity in case of *P. vulgaris* (Ruschel *et al* 1968).

In spite of exceptions, the general conclusion appears to have been reached that liming is unimportant for tropical legume production and that even on acid infertile soils sufficient Ca will likely be applied when triple superphosphate is used as the P source. It is commonly accepted that P additions are needed in most cases for optimum production of tropical legumes, and positive responses to P are almost universally found.

The present field study was undertaken to determine the effect of lime and phosphorus on the growth of cowpeas on an acid ultisol which has a great potential of having greater quantities of exchangeable Al in soil solution.

Materials and Methods:

The experiment was conducted on Piarco Fine Sand, a member of the fine sandy, clayey, kaolinitic, isohyperthermic family of aquoxic Tropudults at Wallerfield. The surface 0-15 cm had a pH of about 4.6-5.0 while the 15-30 cm had a pH of 4.7-4.8 in KCl. The KCl-extractable Al saturation varied from 40-80% in the top soil and 63-84% in the subsoil (Tables 1 and 2).

The treatments consisted of factorial combinations of 0, 4 tons/ha (88% $CaCO_3$, and 60 mesh) and 20% triple supersphosphate to supply 0, 20, 40 and 80 kg/ha P. Plots of 3x3.6 m^2 were arranged in a randomized complete block design with four replicates. The treatments were applied

along with a basal application of 30 kg/ha K and 30 kg/ha N as muriate of potash and urea respectively, and Zn was foliarly sprayed twice as Zn $SO_4 \cdot 7H_2O$ at 0.1% w/v solution.

They were seeded to cowpeas (Vigna unguiculata) at 4 seeds per stand in 50 cm rows at 15 cm apart. The seeds were inoculated with cowpea strain 13B originally isolated from Piarco Fine Sand. The seedlings were thinned to one per stand. Soil samples (0-15 cm and 15-30 cm) were taken at time of planting and at harvest and analyzed for pH, Ca, Mg and P from selected plots.

There was excessive rainfall during the growing season. To provide adequate surface drainage, camber beds and ridges were made.

Results and Discussion:

Examination of treatment means of the grain yields suggested that phosphorus application greatly increased the grain yield of cowpeas, with the greatest response being at the first increment of P (20 kg/ha P) on both the limed and unlimed treatments. The grain yield increased from 400 kg/ha in the control to 865 kg/ha at 20 kg/ha P (Table 3 and Figure 1). Subsequent P increments had very little or no response to the first increment.

Lime had no effect on grain yield. It has been stated by several workers that ordinary superphosphate will adequately satisfy the Ca requirements of tropical legumes, making liming unnecessary (Norris, 1958; Dobereiner, 1966; Ruschel et al 1968 and Spain 1975). In the present study the failure to responses of lime applications and high P applications might have been due to nutrient imbalance, of which Zn deficiency is suspected. This was reflected by the appearance of what looked like Zn deficiency symptoms. There was a delayed maturity of over 40% of the grain, which is one of the effects caused by Zn deficiency.

Literature Cited;

1) Dobereiner, J. 1966. Manganese toxicity effects of nodulation and nitrogen fixation of beans (Phaseolus vulgaris L.) in acid soils. Plant and Soil 24: 153-166.

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4) Spain, J.M. 1975. Forage potential of Allic soils of the humid lowland tropics of Latin America. p. 1-8. In Tropical forages in livestock production systems. Amer. Soc. Agron. Spec. Publ. No. 24., Madison, Wis.

Table 1: Estimations of aluminium saturation in KCl-extracts of the ultisol at Wallerfield

Sample 1/	pH	Ca	Mg	Al	Σ Cations	% Al
		me/100 g				
0-15 N	5.0	1.60	0.61	1.50	3.71	40
15-30 N	4.8	1.00	0.42	2.44	3.86	83
0-15 S	4.6	0.40	0.19	2.37	2.96	80
15-30 S	4.7	0.35	0.17	2.69	3.21	84

Table 2: Some chemical analyses of the soil samples from Wallerfield 2/

Sample 1/	P	Ca	Mg	K	Zn	% O.M.	% O.M.
	ppm						
0-15 N	2.0	275	70	30	1.5	3.4	0.22
15-30 N	1.5	175	55	35	1.0	2.2	0.15
0-15 S	1.0	75	30	15	1.5	2.2	0.14
15-30 S	1.0	50	25	15	1.0	1.6	0.08

1/ 0-15 cm and 15-30 cm is depth in cm
N and S designates north and south respectively to show the gradient in nutrient levels as related to proximity to the pig pen which is N of the experimental site.

2/ NH_4OAc - extractable cations.

Table 3: The effect of lime and phosphorus application on the grain yield of cowpeas (*Vigna unguiculata*)

Treat/Rep.	I	II	III	IV	Mean
L_0 P_0	544	426	265	314	387
L_0 P_1	454	926	1085	956	855
L_0 P_2	1013	1149	880	1013	1014
L_0 P_4	850	760	1000	698	827
L_4 P_0	687	478	294	174	408
L_4 P_1	914	767	1017	777	869
L_4 P_2	702	1086	832	817	859
L_4 P_4	450	1118	1022	893	871

A factorial analysis of variance indicated that there are no significant differences in yield resulting from lime treatment; but a significant difference was found for phosphate treatment ($P < 0.001$). No differences were established between P_1, P_2 and P_4.

2) Yield and response of corn to nitrogen following fallow, corn and cowpea:

Introduction:

Legumes contribute nitrogen to non-legumes in two ways. First, they may be associated with an intercropped non-legume, and second, the legumes may contribute to a succeeding non-legume through residual N remaining in the form of soil organic matter or plant residues. The attention is on the changes in organic N in the soil under three conditions when a non-legume succeeds legumes (a) green manures; (b) pasture/forage; and (c) grain legume. The biggest assumption one makes when dealing with residual N is that the organic N will mineralize in the legume residues (tops and roots) over time. The basic rationale is that the value of crop residues to succeeding crop is the product of decomposition factor and quantity of residue. A non-legume will benefit more following green manures, and these can be used in fallow plots. Less N is contributed from grain legumes since as much as 80% N is lost in the harvest (Hammond et al 1951).

The purpose of the present experiment was to determine the response of corn to residual and/or fertilizer N following fallow, corn or cowpeas. Both corn and cowpeas (blackeye peas) are important in human nutrition in Trinidad.

Materials and Methods:

Plots of 36 m x 4 m were divided into 3 sections of 12 m long. One section was left under fallow and the other two were planted corn at 90 cm x 30 cm and cowpeas (Vigna unguiculata), replicated four times in major season. Muriate of potash at 60 kg/ha K, triple superphosphate at 100 kg/ha P were broadcast in all plots and rotovated under at 15 cm before sowing. Weed control was done regularly in all plots.

In the minor season all plots were seeded to corn at 75 cm x 30 cm. The plots were subdivided into subplots which were fertilized with urea at 0, 30, 60 and 120 kg/ha N. The statistical design was a randomized complete block design with a split plot arrangement of units, with the major season crops (fallow, corn and cowpeas) forming the whole plots and N levels the subplots. A basal treatment of 30 kg/ha K as muriate of potash and 40 kg/ha P as triple superphosphate was banded with fertilizer N at time of planting. The 120 kg/ha N treatment was split into 60 kg/ha N applied at time of planting and 60 kg/ha N side dressed after four weeks.

Grain yield and plant uptake of N will be used as a measure of available N from fallow, corn and Vigna. Yields of the former fallow plots will furnish a standard curve. To data only the grain yield data are reported.

Results and Discussion:

Corn yields in the major season were 51% higher than in the minor season despite the fact that fertilizer N was applied in the minor season. The lower cowpea yields in Rep. I may be attributed to nutrient imbalance.

Although the differences in corn yields following fallow, corn or Vigna are not very spectacular, it clearly shows that Vigna has a slight advantage over fallow and has even a greater effect over corn following corn. The over all averages are in the order of 2514, 2810 and 2982 kg/ha grain field of corn-corn, fallow-corn, or Vigna-corn respectively. (See Tables 4 & 5 and Figure 2.)

The present exercise shows that Vigna is more efficient and economical in its use of soil N than corn by an amount equivalent to 81 kg/ha of fertilizer N or fallow by an amount equivalent to 45 kg/ha N. Shrader et al (1966) pointed out that a crop that followed a good legume crop rotation benefited to the extent of better than 110 kg/ha N once the legume residues are returned to the soil. On the other hand, Bartholomew (1972) contends that the use of leguminous crops to supply N may not be justified in that the cost of N supplied by leguminous crops in terms of labor and land use, is often too high to compete with fertilizer N except where fertilizer is expensive and difficult to get. Besides this, leguminous crops cannot supply enough N to meet the needs of modern high yielding crops. This is supported by Lyon and Bizzell (1934).

The reasons why grain legumes like Vigna don't contribute greater quantities of fixed N to non-legumes may be that: (a) a major portion of the N accumulated by the plant is removed in the grain and (b) the mineralization of soil N under grain legumes is likely to be high and hence the potential decline in soil organic N is fairly high (Wetsclaar, 1973).

One would conclude from the rather meager data set available that substitution of a grain legume for a non-legume in a cropping sequence is likely to have any but a minor effect on the N economy.

Table 4: Grain yield in the major season (kg/ha)

	Replicates				
	I	II	III	IV	Mean
Cowpea	260	865	687	647	615
Corn	4866	4724	3590	3543	4181

Literature Cited:

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5) Wetsclaar, R., Jackson, J. and Chaplin, G. R. 1973. Nitrogen balance in crop systems in tropical Australia. Soil Biol. Biochem. 5: 35-40.

Table 5: The effect of N application on corn yield following corn, fallow or *Vigna*, kg/ha

Treatment	Replicates				Mean
	I	II	III	IV	
F N_0	1602	2712	2385	3319	2506
F N_1	2558	2830	2796	2264	2612
F N_2	2683	2450	2741	3322	2799
F N_4	3277	3745	3348	2925	3324
C N_0	2051	2288	1420	2502	2065
C N_1	2054	2638	1831	3278	2450
C N_2	1938	2765	2192	3328	2655
C N_4	2278	3626	2820	2976	2987
V N_0	2688	2622	2535	2976	2705
V N_1	2312	3404	2778	2885	2845
V N_2	3138	2788	3030	3182	3034
V N_4	3858	3520	2533	3468	3345

Significant effects of both major season treatment (P=0.05) and nitrogen fertilization (P=0.01) were found.

3) The effect of Rhizobium and fertilizer N on soybean and cowpea grain yield and biological N_2 fixation on a Piarco fine sand:

Introduction:

Grain legumes such as soybeans (*Glycine max.*) and cowpeas (*Vigna unguiculata*) are expected to receive most of their nitrogen supply from symbiotic N_2 fixation. Responses to fertilizer N by grain legumes have been inconsistent. However, it has been shown that some N is needed at the initial stages of grain legumes (Agboola, 1978). This is true in the tropics where torrential rainfall and high temperatures cause rapid loss of soil N through leaching and volatilizaton. On the other hand, it is possible to select strains of *Rhizobium* which are both tolerant to stress conditions found in the soils of the tropics, e.g. acid soils, high temperatures etc. These strains will effectively nodulate legumes and be able to fix N_2 required not only for the vegetative growth but also for grain production. This will depend on the effectiveness and efficiency of the *Rhizobium japonicum* or the cowpea *Rhizobium* strains present in the inoculum and/or soil, given adequate environmental and soil factors.

There is limited available data on the effect of N application and/or incoculation of soybeans and/or cowpeas on grain yields and N fixation in Trinidad. It has been shown on some soils of Trinidad that fertilizer N application increases grain yields (Brathwaite, 1974). In the present study, the purpose of the investigation is to observe the effect of fertilizer N and/or *Rhizobium* strain inoculations on the grain yields and symbiotic N_2 fixation of soybeans and cowpeas on a Piarco fine sand.

Materials and Methods:

The experiment was conducted Piarco fine sand (for detailed information see Experiment I on lime-phosphorus) as a randomized complete block design. Treatments consisted of factorial combinations of fertilizer N as urea at the rates of 0, 60 and 120 kg/ha N banded, and *Rhizobium* strains included:

Rh_1	= no inoculum
Rh_2 and Rh_3	= 3I-1b-138 and Soy 13B respectively for soybeans and these strains were imported from the U.S. and S7C and 136 isolated from Princes Town and Piarco fine sand respectively for cowpeas.

Basal treatments included lime at 3 tons/ha (as $CaCO_3$, 88%, 60 mesh), muriate of potash at 60 kg/ha K, triple superphosphate at 100 kg/ha P and magnesium sulfate at 50 kg/ha, which were broadcast and rotovated under at 15 cm before planting. During the growth period zinc sulfate was foliarly sprayed twice at 0.1% w/v solution.

The plots were seeded to soybeans, Jupiter variety (Glycine max.) on June 24, 1977 and cowpeas, California 5 (Vigna unguiculata) on June 23, 1977 at 4 seeds per stand and thinned to 1 seedling in 50 cm rows at 15 cm apart. The plots were 6 m x 3.6 m. The seeds were wetted with Rh_2 and Rh_3 treatments including blank the night before seeding.

During the week of sowing, torrential rains caused flooding despite the fact that camber beds were made, and as a result there was extremely poor germination. The crops (seedlings) were destroyed and ridges were made on camber beds at 50 cm apart to facilitate more surface drainage. The second seeding was on July 13 and 14, 1977 for cowpeas and soybeans respectively.

After one month of growth, destructive harvesting was done from one half of each plot (3 m x 3.6 m) at 3 plants per plot. This was repeated one more time for cowpeas after 2 weeks, whereas for soybeans, sampling was repeated 3 more times at 2 week intervals. The plants were harvested to determine nodule count, plant weight and subsequently N concentration and/or uptake. Grain yield was determined from the other half (3 m x 3.6 m) of the plots. To date only the nodulation results, N content, in the first two sampling periods for soybeans only, and grain yields are reported.

Results and Discussion:

Table 6 (and Figure 3a and 6) presents the results of nodule counts as affected by different rhizobial strains and/or levels of N. There were significant differences between no inoculation and inoculation during the first two sampling periods on the soybean plants. The nodule count on the soybean roots showed a delayed nodule formation in the uninoculated plots (Rh_1) at all fertilizer N levels and that there was increased nodulation with time. There are several explanations to this. First, there might have been contaminants from inoculated plots (Rh_2 and Rh_3) to Rh_1 plots during weeding, thinning and destructive sampling, although great precautions were undertaken by sterilizing feet and hands of the workers and also of the tools used with ethyl alcohol. Second, there might have been indigenous japonicum rhizobia

in the soil in low numbers and that with time these multiplied to cause effective nodulation. Generally, it is reported that R. japonicum is not always present where soybeans have never been grown previously. Inoculation with Rh_2 or Rh_3 greatly increased nodulation throughout the sampling period. Statistically significant differences were found in period one and two for Rhizobium treatments ($P < 0.01$), but not three and four. No differences among nitrogen treatments were found.

On the other hand, nodule count in cowpeas was already high at 33 days and that there were no significant differences between treatments at this sampling. At 42 days the nodule count was so low that the sampling was discontinued in the cowpea treatments since most of the nodules were already decaying. Cowpea rhizobia are always in abundance in this soil, and this is attributed to the fact that there were other wild legumes that had nodules and that they cross nodulate cowpeas. As opposed to soybeans, cowpeas are fast nodulators.

Tables 7 and 8 (and Figures 4 and 5) present data on the effects of Rhizobium inoculation and/or fertilizer N application on N uptake of soybeans. At the first sampling there was a slight increase in N uptake with increased fertilizer N. With time, the effect of fertilizer N was greatest in Rh_1 treatments followed by Rh_2. There was no significant difference between N treatments in Rh_3 treatments.

The grain yields of both soybeans and cowpeas showed greatest responses to first increment of fertilizer N (60 kg/ha N) at all Rhizobium treatments (Tables 9 and 10). There was a slight decrease in grain yields at 120 kg/ha N over the first increment. It is important to note here that increased N application over and above 60 kg/ha reduces N content of the plant material (Appendix Table 9).

Although with cowpeas strain 13B (Rh_3) gave slightly higher grain yields than did S7C (Rh_2) or non-inoculated plants (Rh_1), the difference was not significant ($P = 0.084$). It may be that the high variability among replicates has obscured a real difference in inoculant treatments with cowpeas. Rh_3 was orignally isolated from Piarco Fine Sand and is presumably adapted to these soil conditions. Perhaps the indigenous rhizobia (treatment Rh_1) along with more effective strains. With soybeans, Rh_1 gave almost 50% more grain yield than either Rh_2 or Rh_3. The explanation to this may be that the strains originally present, though in low numbers initially, were more effective and efficient in the N_2 fixation than introduced strains. This is reflected in the

N uptake (Table 8) in Rh_1. This stresses the point that indigenous strains may be more adapted to the soil and environmental conditions, and this explains why Rh_3 is more effective than Rh_2 in cowpeas since Rh_2 was isolated from Princes Town soil. The effect of several complex factors, isolated or interacting, and inherited properties of rhizobial strains determine their behavior in the soil (Jardim Freire, 1976). Another school of thought is that late nodulation in Rh_1 would provide enough N for grain yield production in soybeans.

The present study proved that the terms effective and ineffective are inadequate to describe nodulation responses. This is so because Rhizobium strains differ in effectiveness or ability to produce nodules and differ in efficiency or ability to fix atmospheric N_2. A correlation of nodulation and N_2 fixation characteristics with plant properties is essential. This would include a determination of the number, size, weight and color of the nodules and also the N uptake of soil and atmospheric N.

Table 6a: The effect of Rhizobium japonicum inoculation and fertilizer N application on nodule count per plant of soybeans.

Sampling period	Treatments								
	N_1			N_2			N_3		
	Rh_1	Rh_2	Rh_3	Rh_1	Rh_2	Rh_3	Rh_1	Rh_2	Rh_3
First	1	30	16	1	27	9	1	27	16
Second	9	24	19	4	23	15	4	19	15
Third	25	25	18	15	24	26	16	19	21
Fourth	22	28	23	19	30	20	25	20	20

Table 6b: The effect of cowpea *Rhizobium* inoculation and fertilizer N application on nodule count per plant of cowpeas

Sampling period	Treatments								
	N_1			N_2			N_3		
	Rh_1	Rh_2	Rh_3	Rh_1	Rh_2	Rh_3	Rh_1	Rh_2	Rh_3
First	18	20	21	26	18	16	18	14	17
Second	3	9	6	7	11	2	1	9	1

The results in this table averages from 12 plants = 3 plants/plot and replicated four times.

Table 7: Nitrogen uptake at first destructive plant sampling of soybeans (g/3 plants)

Treatment	Replicates				
	I	II	III	IV	MEAN
Rh_1N_1	0.202	0.212	0.090	0.058	0.142
Rh_1N_2	0.171	0.253	0.291	0.146	0.215
Rh_1N_3	0.178	0.152	0.154	0.116	0.150
Rh_2N_1	0.257	0.160	0.170	0.088	0.169
Rh_2N_2	0.298	0.146	0.381	0.275	0.275
Rh_2N_3	0.347	0.270	0.147	0.205	0.242
Rh_3N_1	0.174	0.165	0.150	0.229	0.180
Rh_3N_2	0.349	0.089	0.106	0.289	0.208
Rh_3N_3	0.219	0.246	0.206	0.143	0.203

No significant differences among treatments have been shown for these tests.

Table 8: Nitrogen uptake at the second destructive plant harvest period gm/3 plants

Treatment	Replicates (Blocks)				
	I	II	III	IV	Mean
Rh_1N_1	0.191	0.450	0.138	0.118	0.224
Rh_1N_2	0.493	0.735	0.708	0.860	0.699
Rh_1N_3	0.738	0.735	1.274	0.830	0.894
Rh_2N_1	0.533	0.263	0.535	0.315	0.412
Rh_2N_2	0.785	0.882	0.574	0.584	0.706
Rh_2N_3	0.948	0.690	0.590	0.537	0.691
Rh_2N_1	0.497	0.488	0.511	0.726	0.556
Rh_3N_2	1.045	0.381	0.322	0.719	0.617
Rh_3N_3	0.613	0.988	0.342	0.316	0.565

Analysis of variance indicates that a highly significant difference ($P < 0.01$) is found among effects of nitrogen treatments on plant nitrogen; but no differences caused by Rhizobium treatments.

Table 9: The effect of *Rhizobium japonicum* inoculation and N application on the grain yield - kg/ha

Treatment	Replicates (Blocks)				
	I	II	III	IV	Mean X
Rh_1N_1	965	668	255	410	574
Rh_1N_2	1243	1318	1120	888	1142
Rh_1N_3	1027	1283	835	1073	1054
Rh_2N_1	1000	212	287	67	392
Rh_2N_2	1582	823	348	190	736
Rh_2N_3	285	1090	513	632	630
Rh_3N_1	620	660	343	603	556
Rh_3N_2	788	800	585	567	685
Rh_3N_3	1063	933	180	542	680

Factoral analysis of variance indicates highly significant difference among Rhizobium treatments ($P < 0.01$), and significant differences among nitrogen treatments ($P < 0.05$).

Table 10: The effect of *Rhizobium* inoculation and fertilizer N application on cowpea grain yield - kg/ha

Treatment	Replicates				
	I	II	III	IV	Mean
Rh_1N_1	244	200	140	178	191
Rh_1N_2	651	710	327	20	427
Rh_1N_3	767	476	236	148	407
Rh_2N_1	262	302	73	74	178
Rh_2N_2	792	677	75	201	436
Rh_2N_3	602	499	109	89	325
Rh_3N_1	453	536	243	38	318
Rh_3N_2	1025	546	227	354	538
Rh_3N_3	962	792	173	60	497

Factorial analysis of variance indicates a highly significant difference among nitrogen treatments ($P < 0.01$), and no significant difference between rhizobial treatments ($P=0.084$).

3a. Minor season experiments at Wallerfield:

In the cowpea treatments in the major season Rhizobium - nitrogen experiment, sorghum was planted on the sameridges at the same spacing (50 cm x 15 cm). The purpose of this study was to observe the effect of residual N on sorghum grain yields. The major season soybean plots were divided into two equal sections of 3 m x 3.6 m. The first half was not inoculated while the second half was inoculated with soybean Rhizobium strain 13B (Rh_3) 31-1b-138 (Rh_2) for major season uninoculated plots and Rh_2 plots, and soy 138 (Rh_3) for major season Rh_3 plots.

The results in the minor season show that there was a great increase in soybean grain yields when compared with minor season crop. The main reasons are that management was greatly improved. Phosphorus, potassium and zinc were banded at 40 kg/ha, P, 30 kg/ha K and 5 kg/ha Zn as triple superphosphate, muriate of potash and zinc sulfate respectively. The introduction of zinc might have contributed to increased pod set, since zinc reduces flower dropping. Rain was just adequate for grain legume production since there was not any flooding. On the other hand it was difficult to determine nodule number because the ground was hard to dig. From the few plants that were dug, there was good nodulation in all plots irrespective of the treatment. On the average, inoculation with Rh_3 reduced soybean grain yield (Table 11a and b).

Table 12 presents sorghum grain yield data. There was no difference in grain yields with N treatments. On the other hand, Rh_1 plots had higher sorghum grain yields than the Rh_2 and Rh_3 plots. To interpret these results, the N data of the soil and/or plant material is necessary, which is still be analyzed.

Table 11a: Minor season soybean grain yields in uninoculated plots (kg/ha)

Treatment	Replicates				
	I	II	III	IV	Mean
Rh_1N_1	2917	1500	1676	718	1703
Rh_1N_2	2361	1273	1134	1574	1586
Rh_1N_3	3454	1454	1500	1134	1886
Rh_2N_1	977	1750	2088	1356	1543
Rh_2N_2	2602	2216	1292	958	1767
Rh_2N_3	1116	1630	819	1042	1152
Rh_3N_1	1829	2180	1792	1028	1707
Rh_3N_2	2081	1904	1486	1319	1698
Rh_3N_3	2810	1273	1648	1412	1786

Analysis of variance indicates no significant differences between inoculated and uninoculated plots, or any of the major season treatments.

Table 11b: Minor season soybean grain yields in the inoculated plots (kg/ha)

Treatment	Replicates				
	I	II	III	IV	Mean
Rh_1N_1	2810	1842	1180	458	1572
Rh_1N_2	1954	597	731	1227	1127
Rh_1N_3	727	2616	1088	1361	1448
Rh_2N_1	2620	1227	1282	1356	1621
Rh_2N_2	1481	1509	1180	1208	1344
Rh_2N_3	1537	2037	1319	1890	1696
Rh_3N_1	1546	1042	2000	940	1382
Rh_3N_2	2245	1394	940	1144	1431
Rh_3N_3	2412	1106	1602	1412	1633

Table 12: The effect of major season treatments of cowpeas on the sorghum grain yield in the minor season (kg/ha)

Major Season Treatment	Replicates I	II	III	Mean
Rh_1N_1	3095	2964	1030	2363
Rh_1N_2	3490	1980	1325	2265
Rh_1N_3	2875	2495	1795	2388
Rh_2N_1	3032	2165	1260	2152
Rh_2N_2	3767	1417	1090	2091
Rh_2N_3	2230	1864	1680	1924
Rh_3N_1	3375	2100	1300	2257
Rh_3N_2	2866	2064	1037	1989
Rh_3N_3	1968	2544	1207	1906

A factorial analysis of variance determined that no significant differences occurred among yields as affected by the previous season's treatments - Rhizobium, nitrogen, nor cross effects of the two.

3b. Greenhouse experiment:

The purpose of this exercise was to show whether the nodulation that occurred in Rh_1 soybean plots was due to contamination or due to the presence of the Rhizobium japonicum in low numbers. A simple experiment was set up whereby 24 pots were separated into 2 sets, one set was uninoculated (Rh_1) and the other inoculated with Rh_3. Pots were seeded to soybeans at 4 seeds per pot and later thinned to one plant per pot. Nodule count was done at 2 week intervals from 3 plants (pots) per set.

Table 13 summarizes the nodule count results. Inoculation of soybeans with R. japonicum greatly increases nodulation, and this increases with time. At the end of the sampling period (10 weeks), there was an increase in ineffective nodules. There was very low nodulation in uninoculated pots (Rh_1), and that nodulation almost increased linearly with time, although the number was extremely low as compared to Rh_3 treatments. Effective in the present case means "pink" nodules, which is commonly used as an indication that the nodules are active and are capable of fixing atmospheric N_2.

This exercise concludes that there are few japonicum rhizobia and that they can infect the roots and form nodules. Isolation of this strain and proving its ability to fix N_2 is necessary under the prevailing soil conditions.

Table 13: The effect of inoculation on nodule count on soybeans

Sampling period	Rh_1			Rh_3		
	Ineffective	Effective	Total	Ineffective	Effective	Total
Week 4	2	0	2	21	17	37
Week 6	0	5	5	15	33	48
Week 8	2	4	6	19	56	75
Week 10	3	5	8	17	57	134

F) FURTHER RESEARCH OBJECTIVES ON BNF IN TRINIDAD

From 1977/78 results it can be concluded that grain legumes will respond to fertilizer N in both inoculated and uninoculated treatments; fertilizer N levels higher than 60 kg/ha were not economical. It was also found that nodulation occurs on both soybeans and cowpeas at Wallerfield on a Piarco fine sand although this did not guarantee increased grain yields or symbiotic N_2 fixation. This may be due to the fact that introduced Rhizobium strains are not as effective as the indigenous strains. In fact from the present results it can be concluded that nodulation as such is not a good indicator of the capability of the rhizobia to fix atmospheric N_2. Of importance is the fact that Rhizobium strains which were properly selected from Piarco fine sand and tested for their effectiveness improved grain yields of cowpeas. In case of soybeans, this has to be tested both in the field and the greenhouse. We have to examine inoculant strains for competitiveness and survival under the existing soil and environmental factors, such as low pH; high aluminum in soil solution, high temperatures etc. The following is a set of experiments proposed:

1) Testing new strain (SN_2): Rhizobium japonicum was isolated from uninoculated plots on a Piarco fine sand. A simple experiment will be undertaken to compare uninoculated (Rh_1) and inoculated (Rh_2) treatments at 0 and 30 kg/ha N. This experiment is already underway, but the first seedling failed to show a good emergence since immediately after planting, torrential rains flooded the area. It is difficult to get soybean seeds in the country at present.

2) Cowpea grown after sorghum: Cowpeas were grown in the major season of 1977 after which the plots were planted to sorghum in the minor season. To test whether Rhizobium survived after the sorghum was harvested, cowpeas have been grown again in the 1978 major season. Half of the plots (3 m x 3.6 m) were inoculated with Rhizobium strain 13B (Rh3) and the other half of the plots (3 m x 3.6 m) were not inoculated. Fertilizer N was applied at 0, 30 and 60 kg/ha N.

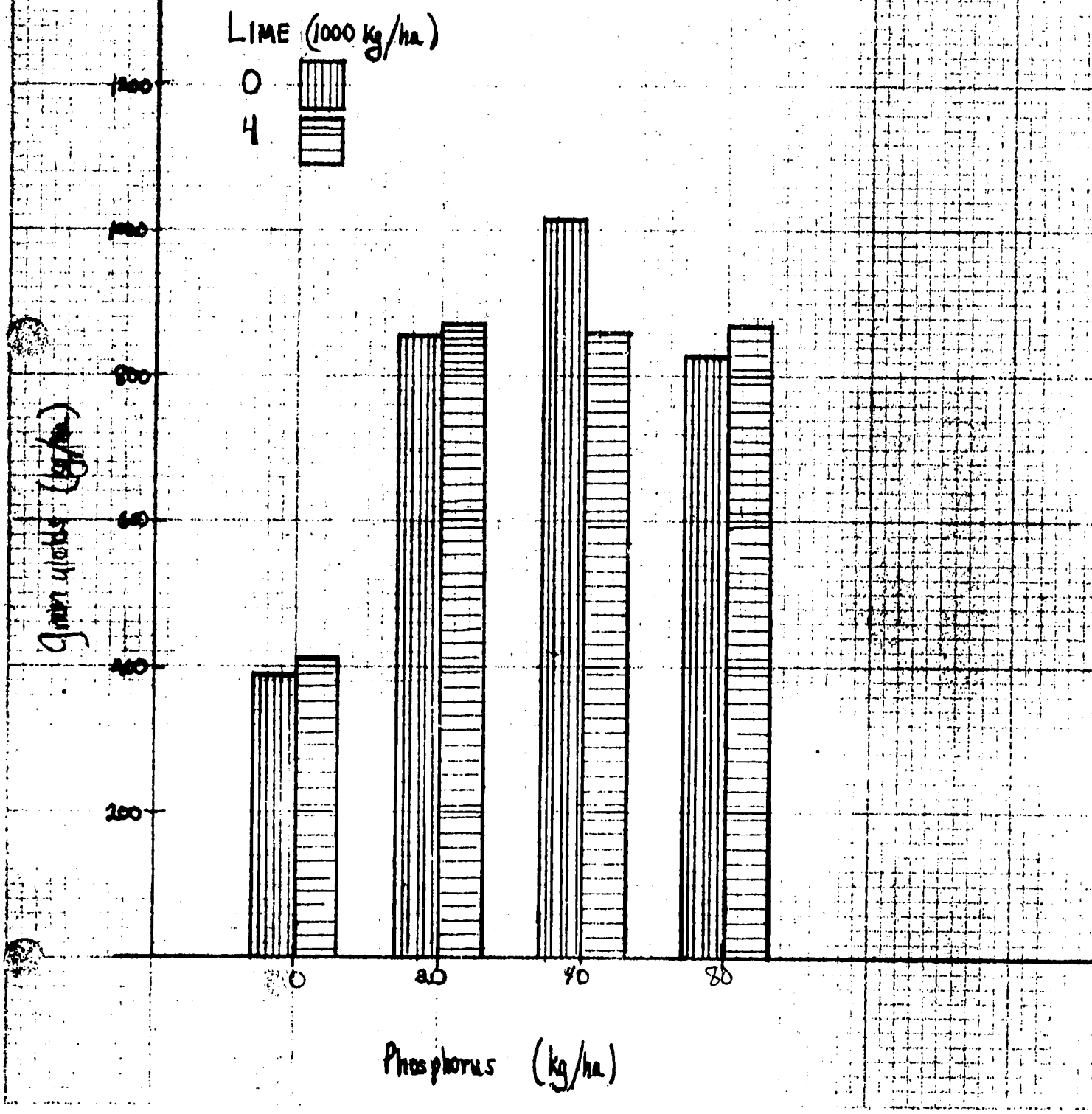
3) Soybeans grown continuously: 1977 major season soybean plots were planted into soybeans again in the 1977 minor season. To test whether effective nodulation can occur, the plots will be divided into two (3 m x 3.6 m each). One half will be inoculated with SN_2 and the other half will not be inoculated. At present this experiment will be of low priority since soybean seeds are hard to obtain in Trinidad.

4) Phosphorus-Zinc experiment: Already, the 1977 major season cowpea crop has shown that low amounts of fertilizer P are required for an economical grain yield production. A simple experiment has been undertaken to improve yields through zince sulfate application at 0 and 5 kg/ha Zn and phosphorus at 0 and 40 kg/ha P as triple superphosphate. Lime has already proven not to be beneficial at 4 tons/ha. In future, a lower lime rate may have to be used.

5) Fallow-corn-cowpea experiment: 1977 major season fallow or corn or cowpea plots were all planted to corn in the minor season of 1977. These will be planted to pigeon peas in the major rainy season of 1978. This is to test whether nodulation can be achieved on this soil once soil nitrates or ammonium have been reduced by growing corn. This experiment was planned in conjunction with Dr. Peter Quilt.

6) Greenhouse experiment: A simple greenhouse experiment will be undertaken to test whether soybeans can nodulate on different soil types without inoculation. The null hypothesis is that *Rhizobium japonicum* is not present in soils that have never previously been grown to soybeans.

Figure 1 Black-eyed pea yields in response to lime and phosphorus - major season [illegible] Waterfield



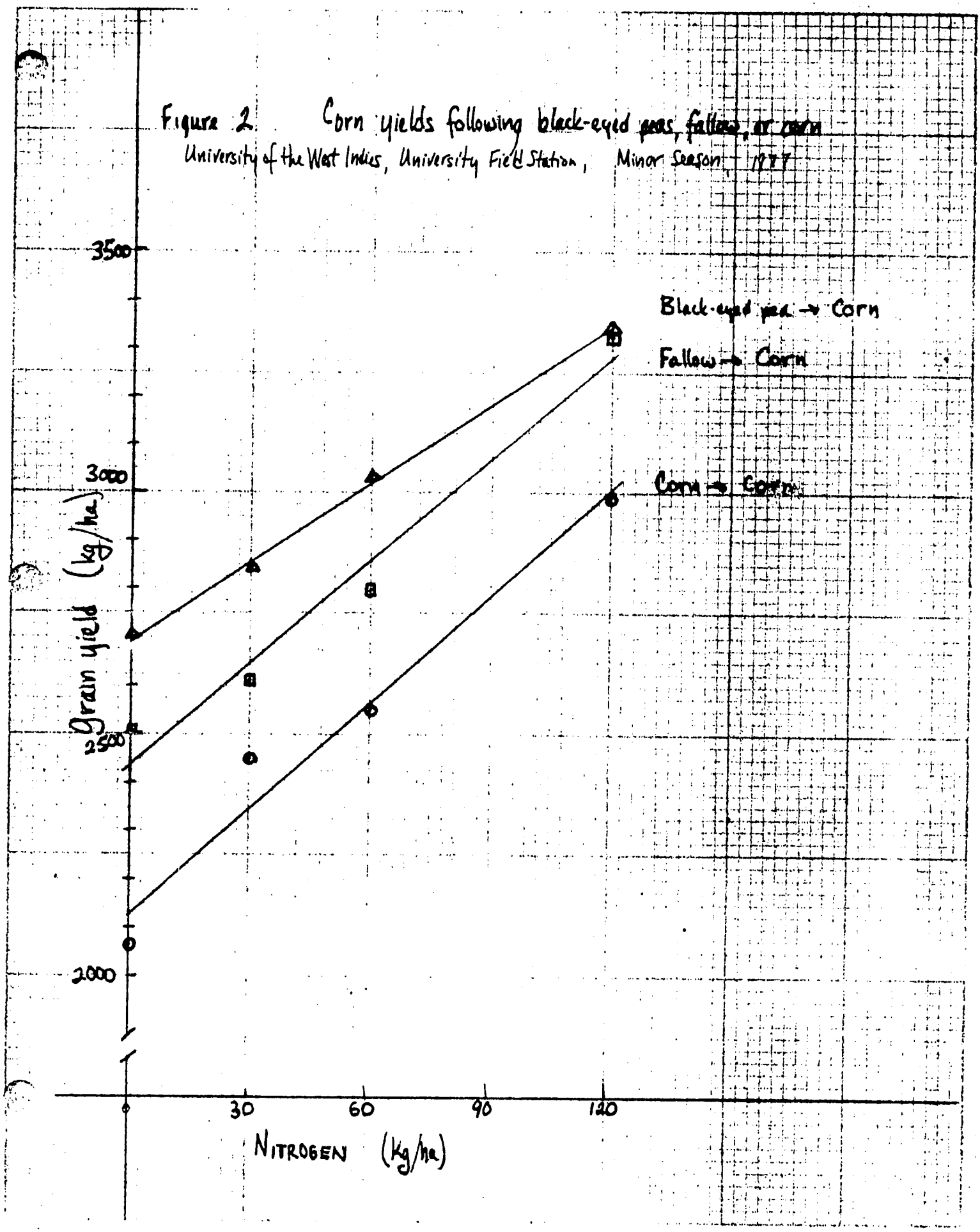


Figure 2. Corn yields following black-eyed peas, fallow, or corn
University of the West Indies, University Field Station, Minor Season 1977
Black-eyed pea → Corn
Fallow → Corn
Corn → Corn
Grain yield (kg/ha)
3500
3000
2500
2000
0
30
60
90
120
NITROGEN (kg/ha)

Nodule counts - Soybean & Cowpea WALLERFIELD 1977

FIGURE 3a

GLYCINE (Soybean)

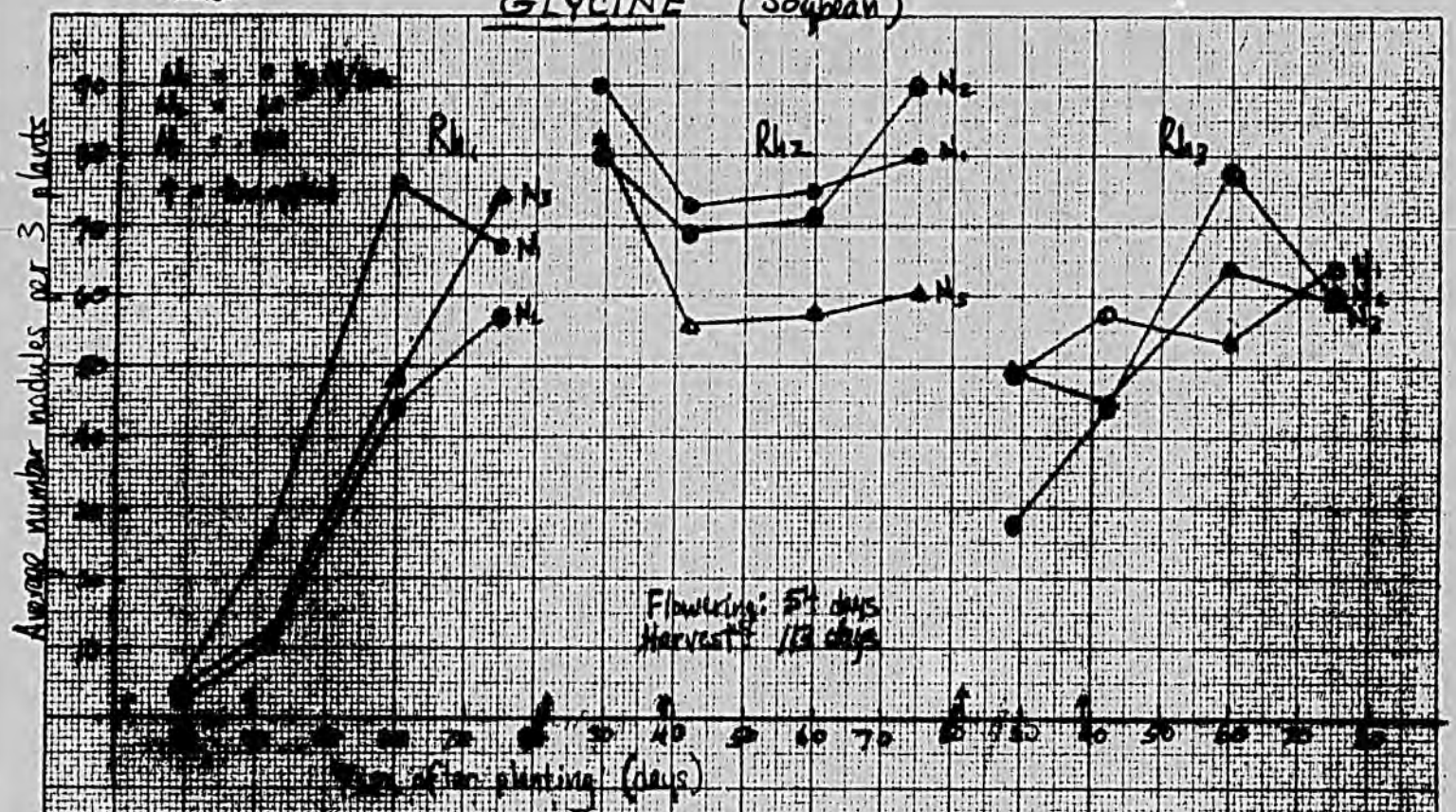


FIGURE 3b

VIGNA (Black-eyed peas)

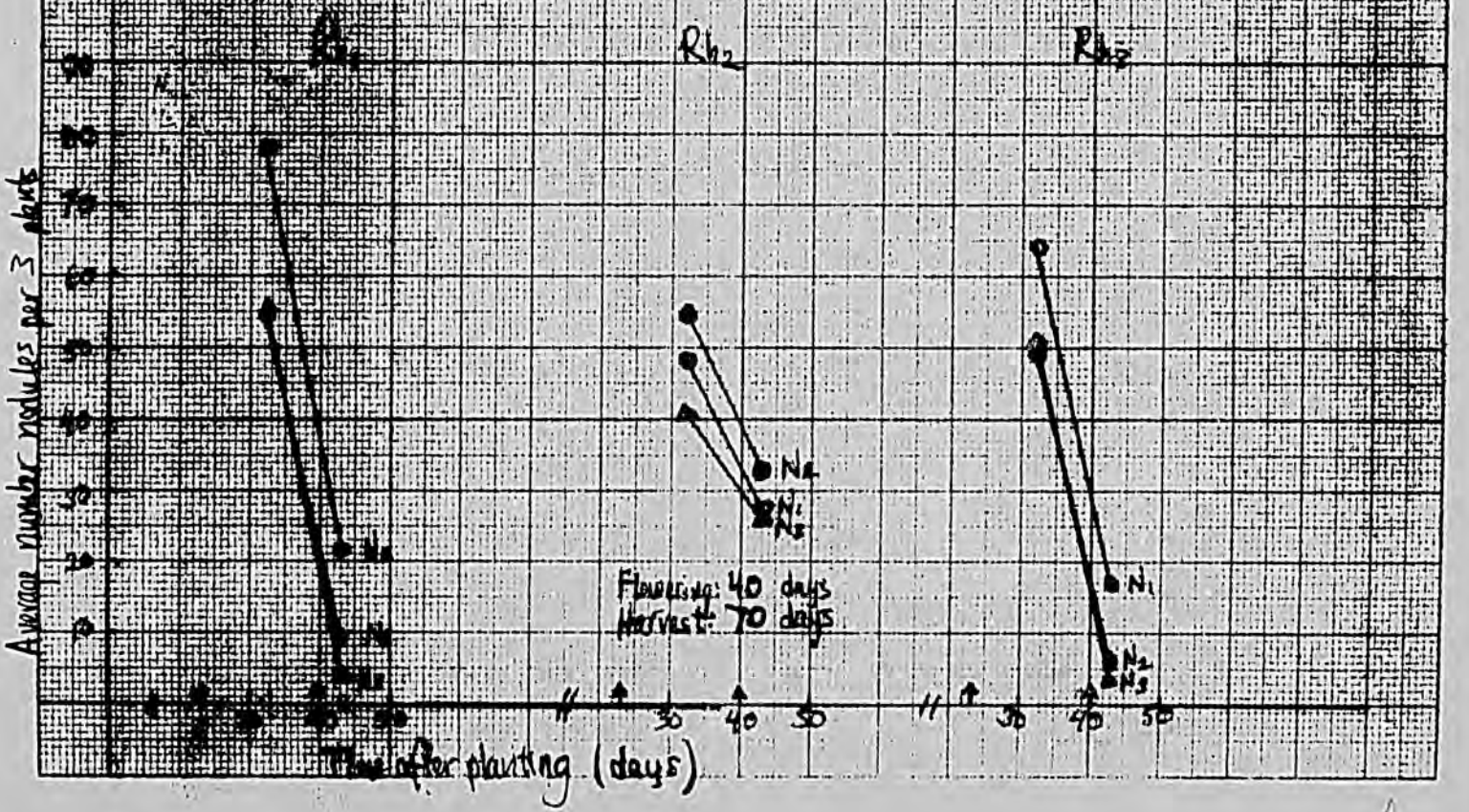


Figure 4 Soybean grain yields major season 1977 Waterfield

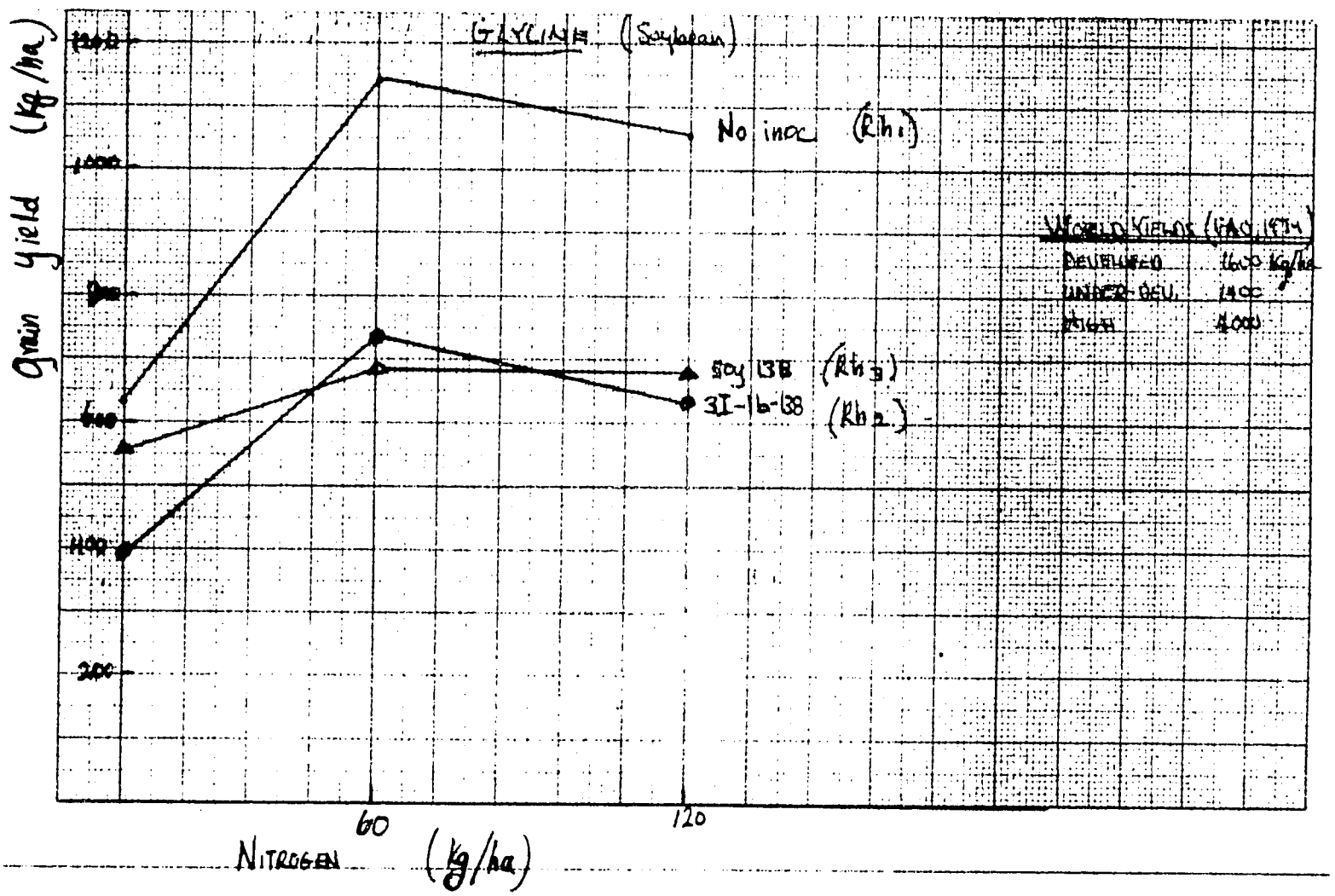
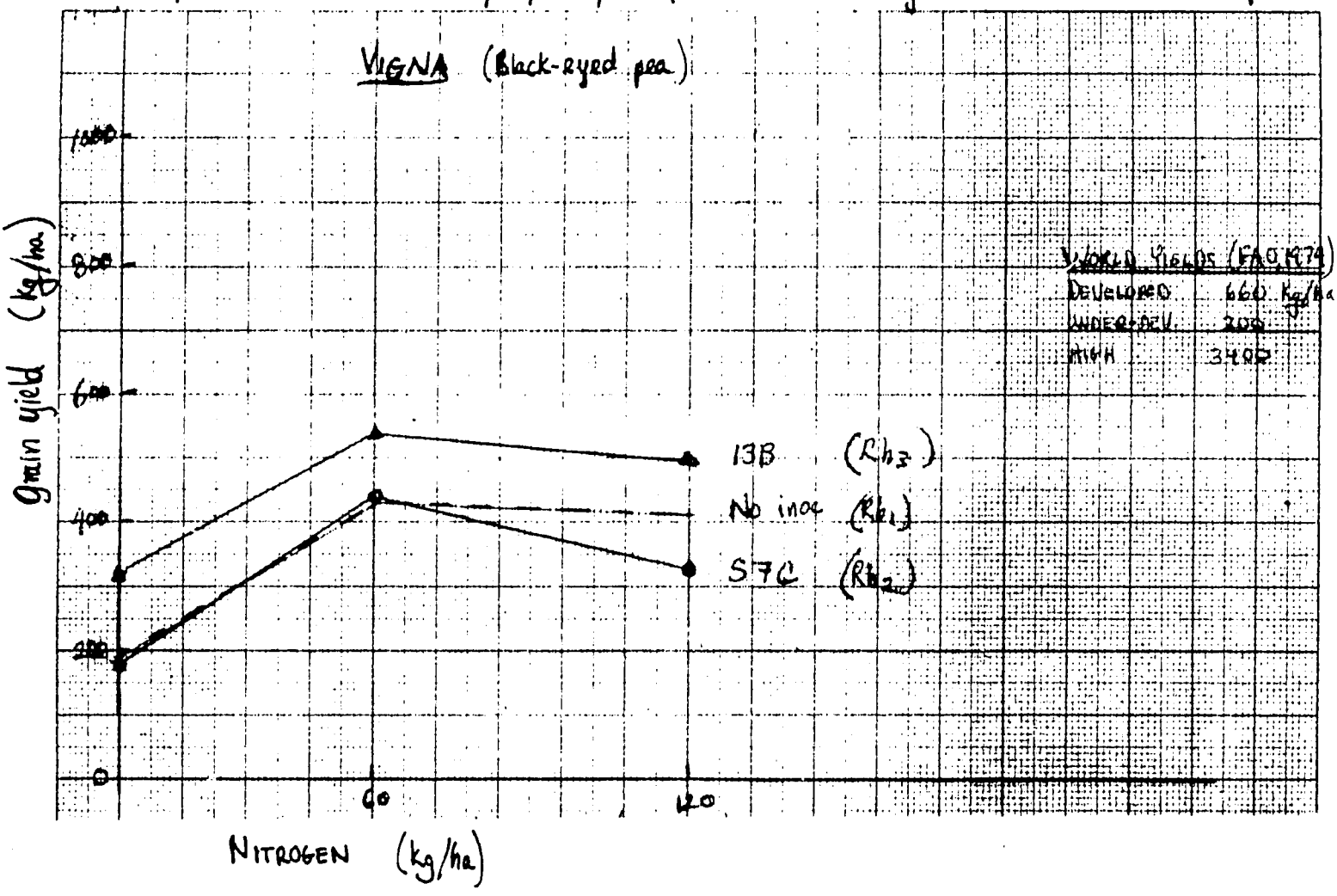


Figure 5 Blackeyed pea grain yields – major season 1977 Wallerfield



A. R. Stobbs - Visit to Washington

Nov. 8 - 15, 1977

My visit was arranged to contact the World Bank, USAID and the USDA in order to discuss two issues

1. Strategy for soil surveys
2. Location of soil surveys which form part of development projects and are not published separately.

Strategy Though generally stimulating discussion, my visit did not produce any marked expressions of opinion. It is clear that generally little thought is given to this subject. Only in USDA was there much coherent thought on the subject and by and large that related rather specifically to North American conditions. In USDA I met Bill Johnson, Klaus Flach and Victor Ling with whom I discussed the forthcoming section in the New Soil Survey Handbook, dealing with the orders of survey. I think their intention of using "Orders" to specify different survey scales and relate that hierarchically to "reconnaissance", "detailed" etc., expressing method, is perhaps worth considering in relation to our project. This is reinforced by the fact that they act as consultants to USAID in soil survey matters.

The World Bank regards itself as a financing agency, and only in the case of irrigation projects is there any specific standard applied to surveys. It is then generally the case that the USBR standards are adopted with little or no modification.

In relation to agricultural research however there is a growing awareness, largely cultivated by Dr. Coulter, of the necessity for a suitable framework for the trans-

ference of agrotechnology. For this kind of work however the Bank generally does not consider investment as an appropriate activity for themselves, although the Bank policy specifically requires a heavy concentration of investment in the rural sector

Data collection

The effort to find project oriented soil survey reports proved more difficult than anticipated. In each organisation, the people to whom I spoke at first expected no difficulty, so the discovery that no normal system of recovery exists has raised considerable interest in the problem. Cliff Orvedal presumed his bibliography to be reasonably complete and was much taken aback when I quoted at random 4 projects none of which he had listed. Both the World Bank and USAID were embarrassed to find that not only could they not quote the surveys undertaken, but they don't even have a comprehensive central list of projects executed from which to start a search. In both cases the starting point would have to be the geographical bureaux who keep their own lists of projects on a country basis. From these the projects likely to contain soil surveys could be identified and the documents then pursued through the filing system.

In the case of the World Bank, locating the documents could prove even more difficult. Although the surveys may have been done at the request of the Bank, they regard themselves as a financing agency and do not keep surplus copies of the survey reports and maps. These are with the contractor who executed the survey and the government for whom it was done. The Bank carry this attitude even further and on completion of a project will discard the copy they hold unless the project offices specifies retention for

future use.

I would estimate that currently about 75% of all soil survey is being carried out on this kind of project basis in the LDC's, involving many millions of dollars. Because of the difficulties facing the LDC government, it is often difficult to impossible to locate the reports in the country, even occasionally impossible to get confirmation that such a survey was carried out (personal experience). This will therefore leave the contractor as the surest source in cases where the Bank has not preserved a copy.

This problem results from the way in which these surveys are published. This generally takes the form of a technical appendix to a development study. Such work is generally given an overall title such as "Feasibility Study of . . . " or "Development Proposals for . . ." or "Regional Development Plan of . . ."; it is produced only in such limited numbers as are considered necessary for the project; and it is classified and therefore not normally available to the public, nor supplied on an exchange basis to professional libraries. Indeed its existence is not usually made public in a way which can ensure it is at least listed in bibliographics or abstract journals.

There is therefore appreciable risk that some of this work can be completely lost to view in quite a short time.

I discussed this problem with Dr. Tej Gill in USAID, but unfortunately not with Dr. W. Peters of Central Projects in the World Bank, who was abroad.

Dr. Gill expressed concern and is interested to know whether this project could assign staff to visit Washington (USAID and World Bank) to list at least a proportion of sucl work. For USAID, arrangements could be made through him, and I would suggest through Dr. Peters for the Bank. Without approved introduction it will not be possible to get access to the Bank's files.

REPORT ON VISIT TO TRINIDAD - May 22-30, 1978

H. Eswaran

Introduction

This visit was made upon the request of Prof. N. Ahmad (Head of Department of Soil Science, University of the West Indies) to USAID. As the objectives of the visit are within the framework of the USAID 211(d) grant to Cornell University, the visit was approved by both USAID and Cornell.

The basic objective of the visit was to evaluate the current status of the Soil Science Department, University of the West Indies, to perform Soil Micromorphological Research and to determine the means by which a program could be initiated to strengthen this section at the University of the West Indies. As UWI is responsible for the West Indian region for providing basic information on soils, a subsidiary objective was to examine the present status of soil survey investigation in the region, especially with respect to application of Soil Taxonomy and to make recommendations towards assisting these investigations. Finally, the opportunity was also used to examine some soils in the field and especially to sample, for detailed characterization at Cornell, the soils on which the Cornell-USAID project on Biological Nitrogen Fixation (field trials) are laid out.

The Status of Application of Soil Taxonomy

The first comprehensive application of Soil Taxonomy to the West Indies was made by Dr. Guy D. Smith in 1973-74 during a project funded by the Organization of American States. A technical report was prepared and the final version is now being published by UWI.

All the soil series mapped in the region were classified according to Soil Taxonomy. During this exercise, Dr. Smith noted the inadequacy of the system and made several proposals for additions. However, Dr. Smith adds, "Uncertainties of the classification exists for most of the series mapped" due to several reasons, the most important of which is the absence of data. Further, he adds, "mineralogical data in particular are lacking in the published soil surveys."

Consequently, though Dr. Smith made a series of attempts to classify the soils, according to Prof. Ahmad, this should only be considered as a preliminary appraisal which should form the basis for a future, more concerted effort to make detailed investigations on the soils.

Soil Taxonomy admits the fact that the classification of soils of the tropics is not as well developed as the rest of the world. Due to the wide spectrum of parent materials, climates, and soil conditions which prevail in the West Indies, we have to agree with the contention of Prof. Ahmad that the region will prove to be a valuable test site for applying Soil Taxonomy.

Soil Micromorphology and Mineralogy

The University of the West Indies has realized the value of this new technique for studying soils and has now invested in equipment for such studies. Although the basic equipment is now available, a few other things need to be added before the laboratory becomes operational.

In addition, staff and technicians have to be trained in the application of the technique. It is hoped that the cooperation of Cornell could be sought for this.

UWI has recently acquired an X-ray diffractrometer for mineralogical analysis. This is the basic equipment for mineralogical studies and in addition, they will need a DTA-TGA equipment. However, systematic mineralogical investigations cannot commence without a full-time mineralogist.

Final Recommendation

On Monday, May 22nd, a discussion was held with Prof. N. Ahmad and Dr. S. Griffith of UWI and Dr. S. Mughogho, Cornell visiting scientist at UWI. Prof. Ahmad expressed clear satisfaction with the current Cornell-UWI project funded by USAID on Biological Nitrogen Fixation. However, he stated that extrapolation of the results of this project and other agronomic projects at UWI to other soils cannot be effective in the absence of more and better characterization of the soils. This applies not only to the West Indies but also to the rest of the tropics. The U.S. has provided Soil Taxonomy as the vehicle for the transfer of such information but the application of Soil Taxonomy is lagging in LDCs. In addition, agronomists from LDCs are not well versed in this classification system and in some cases are even reluctant to use it. This forms, perhaps, one of the biggest stumbling blocks for technique transfer within LDCs - absence of detailed soil information and lack of a common technical language for communication.

The West Indian region presents an unique opportunity to test and develop Soil Taxonomy. The wide range of soils and soil conditions and the proximity to the U.S. coupled with guaranteed cooperation of the UWI are advantages not commonly encountered. The broad spectrum of soil climate will also enable the testing of the model on soil temperature and moisture regimes developed by Prof. A. Van Wambeke. Consequently, a cooperative project funded by USAID will have several far reaching benefits, some of which are:

a) will strengthen the capabilities of Cornell in its tropical soils program,
b) will strengthen the capabilities of UWI in its efforts to train local scientists,
c) will provide some urgently needed basic information on soils of the West Indies,
d) the experience and expertise developed during this project will be highly beneficial in other LDCs with similar ecological conditions.

Some of the objectives of the proposed project could include the following:

a) To develop facilities at UWI for mineralogical and micromorphological studies.
b) Cooperate in the studies on benchmark pedons to apply and improve Soil Taxonomy.
c) Test the model on soil temperature and moisture regimes. As this is a computer developed model, if the soil climate is accurately predicted, then the model could be extended to other LDCs where such data are not available.

d) Make a soil map of the West Indian region according to Soil Taxonomy. The map should be of a sufficiently large scale as to be useful to the local (national) planners. (The presently available FAO-UNESCO soil map of the world does not serve this purpose).
e) Organize training sessions on soil survey and classification with special emphasis on Soil Taxonomy. The sessions should be field oriented to enable soil scientists to identify requirements of Soil Taxonomy in the field. The sessions should also attract agronomists and attempt to develop a dialogue between soil surveyors and agronomists. Scientists from other LDCs must be invited to participate.
f) Finally, Prof. Ahmad has proposed, and I strongly recommend, that a workshop be held in 1979 on "problems and potentials of marginal soils in the West Indies".

It would be ideal if a one-month training session for soil scientists from LDCs (e) is concluded by a ten-day workshop (f). The venue of both the training session and the workshop could be Guiana.

Report on Visit to Malaysia and Thailand

H. Eswaran

Introduction

The following is a report on my visit to Malaysia and Thailand from 6th. January to 27th. January 1978. The purpose of the mission was to make preliminary arrangements for the proposed International Workshop on Soil Classification. This Workshop to be organized by the Universities of Cornell, Hawaii and Puerto Rico, and supported by USAID, is the second of its kind; the first having been held in Brazil in June 1977.

Host organizations and committees

In Malaysia, the Workshop will be hosted by the National Soil Survey of the Ministry of Agriculture. During the International Meeting on Classification and Management of Tropical Soils held in Kuala Lumpur in August 1977, Dr. S. Paramanathan of the Soil Survey of Malaysia had already extended an informal invitation to Dr. Beinroth. The President of the Soil Science Society of Malaysia, Dr. E. Pushparajah, strongly supported this idea.

Subsequent to my visit to Malaysia, it was decided that the host committee will be composed of the following:

Dr. S. Paramanathan .... Chairman

Mr. Lim Jit Sai ..... Secretary

The heads of the soil survey of Sabah and Sarawak, Messers.

Mohinder Singh and Mr. Lim Chin Pang, respectively, will also be coopted into the committee. The other members will be a representative from the Rubber Research Institute, Malaysian Agricultural Research and Development Institute and the Agricultural University. All these organizations are actively involved in the study of Malaysian soils and so their cooperation and participation in the Workshop will be very useful.

Dr. Pushparajah indicated that the Workshop be open to all Malaysian Pedologists. This suggestion concurred with one of our objectives which is to enable the International Scientists to meet the Malaysian Pedologists. However, it was made clear that it was not possible to finance all of them and even for the second part of the Workshop in Thailand, only a few will be financed. Other Malaysians who would want to come to Thailand may do so at their own costs. The number for the latter will also be limited and Dr. Paramanthan will be informed of this.

I propose that the Malaysian Organizing Committee, composed of Dr. Paramanathan, Mr. Lim Jit Sai, Mr. Mohinder Singh and Mr. Lim Chin Pang, be financed by CST for the Thai part of the Workshop.

In Thailand, the Workshop is organized by the Land Development Department, under the leadership of Mr. Samarn Panichapong, Chief of the Soil Survey Division. The host committee is composed of:

Mr. Samarn Panichapong .... Chairman

Mr. Lek Moncharoen ..... Secretary

Mr. Pisut Vicharnsorn ..... Member

Dr. Santhad Rojanasoonthon, of Kasetsart University, though not a member of the committee has indicated his interest in the Workshop. As in Malaysia, many Thai Soil Scientists have indicated their interest in the Workshop and it was mutually agreed, that all be invited to attend.

I propose that the Thai organizing committee and Dr. Rojanasoonthon be financed by the CST for the Malaysian part of the Workshop.

Workshop Program

Appendix I gives the proposed dates and some details of the Workshop. September is the wettest month of the year and the Thais have expressed their dissatisfaction on the choice of this month. It will not be possible to see any of the padi soils during this period. In Malaysia, however, this is a convenient time as the rest of the year is wet.

The duration of the Workshop is fourteen days as against the ten originally anticipated. About seventeen profiles in Malaysian and nineteen in Thailand will be seen. The profile names and their field classification are given in the Appendix I. The emphasis in Malaysia is on Oxisols while in Thailand it is on Ultisols. Soils with Ustic, Udic and Perudic soil moisture regimes will be seen. The problematic soils are those with aquic soil water regimes and these cannot be seen

as they will have a few centimeters of surface water.

In both countries, Soil Taxonomy is being used and it is the desire to adopt it as the official system of classification. However, due to lack of facilities, there is some difficulties in the application of the system. Both countries have expressed the desire to report some of these problems at the Workshop and have also requested that there be some working papers presented by the International delegates. Consequently, it will be useful to devote some time in each country for the presentation of short papers which will also serve as the basis for discussion during the Workshop.

Soil Analyses

The Malaysian soils have all been analyzed and so little further work is necessary. In Thailand, however, all the soils will have to be analyzed. The routine physico-chemical characterization will be done in Thailand. Some samples will also be sent to USDA. Lincoln, Nebraska, for comparison. The clay fraction of the soils will be separated in Thailand. A small portion will be sent to Dr. Ikawa, Hawaii for XRD, DTA and TGA analysis. Another portion will be sent to Gent for TEM analysis. Samples for micromorphological study were already brought by me to Gent for making thin-sections. The TEM and the micromorphological study will be the contribution of the University of Gent at the Workshop.

Budget Considerations

No special funds are available in both countries to subsidise any part of the Workshop, including ground transportation. Request for such funds should normally be made about two years in advance. The contribution by both countries will be mainly in the form of locating, sampling and analyzing the soils, preparing the tour guide and providing the necessary facilities during the Workshop.

In both countries, the conference halls are located in the respective hotels. If 30 to 50 people stay in the hotel, the use of the conference hall is free. In Bangkok, the Asian Institute of Technology presents excellent facilities for a conference. It is, however, too far from the city (65 km) and we have to pay for the conference facilities. I thus opted for the Asia Hotel.

The average cost of the hotel is $20 in Thailand and $25 in Malaysia. It is much cheaper in the countryside. About $10 per day is estimated for breakfast, lunch and dinner. The Malaysian prefer to charge a flat rate of about $120 per person for the four day field tour. This will cover lodging, meals and transport. Depending on the number of participants, the amount will be much less. In Thailand, the five day tour will cost about the same. I think the prices are well within the per diem that the sponsored participants will receive.

Other Remarks

On my return from this mission, I received a letter from Prof. Dr. Frank Moormann requesting to include Sri Lanka in the proposed Workshop. He states "The advantages are several. First, in Dr. Chris Panabokke (Assoc. Director of Research, Dept. of Agriculture, Peradenya, Sri Lanka) who is one of the foremost soils people in Asia, and quite conversant with Soil Taxonomy. Second, much good work has been done and many profiles are described and well analyzed. Third and most important, the island offers within a reasonable distance a range of soils, going from perudic to ustic over several parent materials." Frank had already mentioned this to Van Wambeke.

Perhaps it is still not too late to change our program. If we wish to change from the proposed (Appendix I), we have two alternatives.

Alternative I is to eliminate Malaysia. As the Malaysians have just hosted an international conference in 1977, they will not mind too much. Further, to have the meeting in the three countries will involve time in travelling though costs will not be too different.

Alternative II is to reduce the program in Malaysia and Thailand so that we still have a 14 day Workshop. Appendix II gives this proposal.

Appendix I — Workshop Program

August

Friday 25th

Delegates arrive in Kuala Lumpur Conference Hall and lodging at Merlin Hotel.

Saturday 26th

Opening ceremony by Director of Agriculture
Technical sessions.

Sunday 27th

Soil Tour. Kuala Lumpur to Temerloh.

~~Pedon M1~~	~~Chat Series~~	~~Typic Paleudult~~
Pedon M2	Benta Series	Typic Tropudulf
Pedon M3	Ulu Dong Series	Typic Paleudult

Lunch in Raub

Pedon M4.	Lanchang Series	Typic Paleudult

Night in Temerloh

Monday 28th

Temerloh to Kuantan

Pedon M5	Segamat Series	Haplic Acrorthox
Pedon M6	Kening Series	Typic Paleudult
Pedon M7	Bungor Series	Typic Paleudult
Pedon M8	Lunas Series	Orthoxic Paleudult

Lunch at Kuantan

Pedon M9	Kuantan Series	Haplic Acrorthox
Pedon M10	Beserah Series	Tropeptic Haplorthe:

Night at Kuantan

Tuesday 29th

Kuantan to Kluang.

Lunch at Kluang.

Pedon M11	Senai Series	Haplic Acrorthox
Pedon M12	Jerangau Series	Haplic Acrorthox
Pedon M13	Batu Anam Series	Oxic Tropaquept

Night at Kluang.

Wednesday 30th

Kluang to Kuala Lumpur

Pedon M14	Patang Series	
Pedon M15	Prang Series	Typic Eutrorthox Haplic Acrorthox

Appendix I — Workshop Program (Cont'd)

August

Lunch in Malacca

Pedon M16.	Malacca Series	Tropeptic Haplorthox
Pedon M17.	Kuala Pillah Series	Haplic Acrorthox

Night in Kuala Lumpur

Thursday 31st

Technical session
Closing dinner by Soil Science Society of Malaysia.

September

Friday 1st

Kuala Lumpur to Bangkok
Lunch in Bangkok
Lodging at Asia Hotel

Saturday 2nd

Opening ceremony by Director of Agriculture.
Technical session.

Night in Bangkok

Sunday 3rd

Bangkok to Nakhon Ratchasima.
Visit to Ayudhaya Temple (To obtain blessings)

Pedon T1.	Pak Chong Series	Rhodic Paleustult

Lunch and briefing at Corn Research Center, Pak Chong.

Pedon T2	Si Khiu Series	Typic Paleustalf
Pedon T3	Warin Series	Typic Paleustult

Night in Nakhon Ratchasima (Sri Surant Hotel)

Monday 4th

Pedon T4	Korat Series	(Arenic) Typic Paleustult
Pedon T5	Yasothon Series	(Rhodic) Arenic Paleustult

Lunch at Nakhon Ratchasima

Pedon T6	Chok Chai Series	Tropeptic Haplustox
Pedon T7	Kula Ronghai Series	Aeric Natraqualf

Night at Nakhon Ratchasima

Tuesday 5th

Nakhon Ratchasima to Chantha Buri

Pedon T8	Ban Cheong Series	Typic Paleustult
Pedon T9	Kabin Burri Series	Petroplinthic paleustult

Appendix I — Workshop Program (Cont'd)

September

Lunch in Kabin Burri

Pedon T10	Bung Chanaut Series	Udic Haplustoll
Pedon T11	Pung Nga Series	Typic Paleudult

Night at Chanthaburi (Eastern Hotel)

Wednesday 6th

Pedon T11a	Aeric Plinthaquult (Tentative)	
Pedon T12	Phuket Series	Tropeptic haplorthox
Pedon T13	Huai Pong Series	Typic Paleudult
Pedon T14	Tha Mai Series	Haplic Acrorthox
Pedon T15	Klong Chak Series	Typic Paleudult

Lunch at Chantaburi

Afternoon. Technical session.

Night at Chantaburi

Thursday 7th

Chantaburi to Pattya

Pedon T16	Kho Hong Series	Typic Paleudult
Pedon T17	Chalong Series	Oxic Plinthustult

Lunch at Travel Lodge (Mab Ta Pud)

Pedon T18	Ban Bunt Series	Arenic Paleustult
Pedon T19	Mab Bon Series	Typic Paleustult

Night in Pattaya (Royal Cliff Beach Hotel)

Friday 8th a.m. Technical session
Lunch in Pattya

p.m. Leave for Bangkok

Closing dinner by Land Development Department.

Saturday 9th Delegates leave.

Appendix II	Workshop Program - Second Alternative
August	
Friday 25th	Delegates arrive in Kuala Lumpur.
Saturday 26th	Technical session
[illegible]y 27th	Field Tour
[illegible]y 28th	Field Tour
Tuesday 29th	Leave for Bangkok
Wednesday 30th	Technical session
Thursday 31st	Field Tour
September	
Friday 1st	Field Tour
Saturday 2nd	Field Tour
Sunday 3rd	Field Tour
Monday 4th	Technical session
Tuesday 5th	Leave for Sri Lanka
Wednesday 6th	Technical session
Thursday 7th	Field Tour
Friday 8th	Field Tour
Saturday 9th	Technical session
Sunday 10th	

New York State College of Agriculture and Life Sciences
a Statutory College of the State University
Cornell University
Department of Agronomy
Bradfield and Emerson Halls, Ithaca, N. Y. 14850
Telephone: 607-256-5459

F-1

July 15, 1977

MEMORANDUM

TO: Dr. R. Lucey
Dr. J. Metz, Jr.

FROM: A. Van Wambeke

RE: Report visit to Port au Prince, Haiti
July 11-14, 1977

1. The purpose of the visit was to explore the possibility to conduct a case study on the status of soil resource inventories in Haiti. The operation would fall within the objectives of our 211(d) grant extension.

2. Interviews were held with Mr. Garvey, Agricultural Officer USAID, Haiti; Mr. Nagy, AID/Engineering, Haiti; representatives of the Ministry of Agriculture; the dean and staff members of the Faculty of Agriculture and Veterinary Sciences at Damien. All comments were favorable.

3. Mr. T. Forbes will collect information on soil, climatic and géological surveys; he will also examine local facilities i.e. office space, purchase of a vehicle in Haiti, and housing conditions.

4. The laboratoire de chimie du sol of the ministry of agriculture will probably be reorganized; the college of agriculture in Port au Prince will receive assistance from the Canadian Agency for International development; USAID will start at the same institution a program adding a fifth year to complete the curriculum leading to the degree of Ingénieur Agronome; USAID/Eng intends to present for fiscal year 1979 a comprehensive cadastral survey at 1:10,000 for the whole country, including a natural resources inventory. All groups expressed great interest in our visit, and its objectives.

5. I have explained the purposes of a possible Cornell operation in Haiti which is essentially a test for our inventory evaluation methodology. The study would have

98

three main outputs: (1) present status of soil survey; (2) estimate of the needs for basic soil information in development planning; (3) strategies to fill the knowledge gaps.

6. There are enough soil maps in Haiti to be evaluated; they are very diverse in scales, legends and reports. There is apparently no government institution in charge of soil inventories, and most surveys have been carried out by international foreign agencies.

7. Depending on Mr. T. Forbes' findings, it is planned to conduct the following operations in Haiti:

   a) assign a research support specialist in Haiti for a period of six months; his duties would be to evaluate soil surveys in the field in relation to variability, usefulness and ground truth.

   b) to send two graduate students for six week periods to assist the RSS in his work.

   c) to provide short term faculty support to the operation.

8. The activities described above would be conducted in conjunction with a Haiti institution, preferably the College of Agriculture. It would be necessary to purchase a four-wheel drive vehicle, obtain office space at Port au Prince, and other locations in the field.

9. The final decision will be made upon Mr. Forbes' report.

cc: R. Arnold
T. Forbes
Mr. Garvey
T. Gill

Attachment: list of persons and institutions visited

Haiti - Soil Resources Inventory Study

The Soil Resource Inventory Group of the Agronomy Department at Cornell University has been compiling and testing methodologies of Soil Resource Inventory Evaluation for use in less-developed countries. These methodologies, however, must pass a critical test - their actual use in an LDC environment. It is proposed therefore to make such a test of their potential in the Republic of Haiti. The test will hopefully, indicate strengths, weaknesses and areas for further development and improvement. The following outline attempts to set forth the structure of the in-country evaluation procedure as presently envisaged.

I. Purpose: In-Country Evaluation of Existing Soil Resource Inventories and Suggestions for their Improvement

II. Procedure

A. Make contact with appropriate officials (agriculturalists, planners) and explain purpose of research

B. Compile listing and examples of all soil resource inventories available

C. Select representative examples of soil resource inventories for report evaluation:

1. Define map and legend parameters according to SRI Group's terms

2. Classify maps and legends

3. Evaluate maps and legends

a. By methodology
b. By narrative

4. Assess completeness and utility of reports through evaluation methodology and critical judgement

D. Assess ground-truth of representative examples of soil survey reports

1. Evaluate classification system used in terms of objectives stated or implied

2. Evaluate legend and map unit representation in terms of purity of units

a. Grid sampling of selected area

b. Morphological descriptions of samples

c. Chemical analyses of samples

d. Statistical analysis of results

3. Results of ground-truth checking

E. Facility of taxonomy used to transfer technology locally and internationally

III. Conclusion of Evaluation Procedures

A. Recommendations to Haitiian Government for future improvement of SRI projects

B. Recommendation to Cornell SRI Group for further research and development of concepts and methodology

For this undertaking a certain amount of support (logistical and facilitation of contacts with appropriate officials) will be expected from USAID, as introductions to appropriate government officials from the Ministry of Agriculture, agricultural research organizations, land-use planners and any others with whom it would be necessary to cooperate with for such an undertaking. USAID assistance would be required for transportation including a vehicle for field use to visit any areas selected for study.

Colloque sur l'Amelioration des Systeme de Production Agricole

Problemes relatifs au maintien de la productivite des sols

prepare par

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PROBLEMES RELATIFS AU MAINTIEN DE LA PRODUCTIVITE DES SOLS

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Le point de vue du Pédologue, dans la discussion des systemes integres de production qui soient d'application possible dans la zone sahélienne, est par necessite celui d'un specialiste qui ne considere qu'une partie d'un ensemble de facteurs. Passer en revue les problemes de rotation, de fumure organique et minerale ainsi que d'autres pratiques agricoles que rencontrent les familles d'agriculteurs, est la tache d'un groupe assez important de techniciens. Il ne este par consequent comme solution que celle de faire un effort de synthese des connaissances en matiere de pedologie au sujet de l'utilisation des sols de l'Ouest Africain en mettant l'accent sur les aspects qui interessent en particulier les planificateurs du developpement rural.

Il faudra, pour atteindre ce but, serier les problemes; ils sont groupes par rapport aux trois questions suivantes:

(1) Quelles sont les contraintes majeures imposees par les sols a la production?

(2) Quels sont les moyens techniques mis a notre disposition pour relever ces contraintes?

(3) Comment mettre ces pratiques a la portee des familles de producteurs, tout en limitant la discussion aux mécanismes sur lesquels les pédologues peuvent agir et soient

competents.

A. CONTRAINTES MAJEURES IMPOSEES PAR LE SOL

1. La diversite des types de sol

La diversite des sols se manifeste tant au niveau des cartes generalisees qu'au niveau des dimensions des exploitations individuelles. Par exemple, dix classes de la classification Francaise, subdivisees en 390 unites cartographiques apparaissent sur la carte des sols plubliée dans l'Atlas de l'Ouest Africain (OAU 1971). Sur un total mondial de 26, la FAO reconnait 18 ordres se distribuant en 103 combinaisons diverses. Il n'est par consequent pas etonnant de constater qu'il est difficile de generaliser des normes de maintien de la fertilite qui n'ont ete obtenues que dans une gamme limitee de conditions édaphiques.

La diversité en nombre, qui est en partie le resultat de l'immensite du territoire considéré, se transforme souvent en vue une diversite de contraste quand on limite les observations à un domaine restreint. Deux sols ayant des propriétés diamétralement opposées peuvent se trouver côte à côte dans un même passage. Il est par consequent difficile d'etendre certaines pratiques agricoles ayant fait leur preuve dans un site donne a d'autres sites sans courir le risque de se diriger vers un echec quand on neglige de controler l'equivalence des conditions de sol.

2. Les facteurs limitant de la production

On peut etablir une liste des contraintes qui sont particulierement severes dans la zone soudano-sahélienne. Il

y a eu de nombreux travaux de recherches et d'application; il n'est pas possible d'en faire un inventaire complet.

En matiere d'economie en eau, il faut citer la variabilité du pouvoir de rètention en eau du sol; les vitesses d'infiltration et de perméabilitè dependent de la structure qui est conditionee par la texture, la mineralogie, le taux de matiere organique et par les méthodes de travail du sol.

On attache beaucoup d'importance au volume de sol exploitable par les racines, qui dans de nombreaux cas est limitè par la consistance des materiaux, surtour en terre superficielle sableuse. La deterioration de la structure est moins critique dans les sols ferralitiques et par consequent, la necessite de labours profonds y est sans doute moins grande.

Le maintien de la fertilite dépend d'autre part de la disponibilite des elements nutritifs. Les taux d'azote sont tres variables, quoique generalement bas. Jones (1973) mentionne pour les sols bien draines une moyenne de 0,051% N total dans l'horizon humifere; la variabilite de la teneur en azote est essentiellement liée à la pluviosite annuelle et la teneur en argile.

Les taux de mineralisation de la matiere organique mesuree dans des essais de longue duree n'est pas superieur a 5% par an (Nye et Greenland, 1960; Charreau et Fauck, 1970; Jones et Wild 1975). Il est toutefois evident que la vitesse de decomposition pendant l'annee peut être temporairement nettement plus elevee; elle entraîne des pertes en azote par

l'ixiviation, surtour en début de la saison des pluies. L'azote est sans doute, avec le phosphore, l'element nutritif qui le premier est responsable du déclin des rendements en terre de culture.

Les teneurs en phosphore, et les formes sous lesquelles il est present, varient d'apres les materiaux originels; ils sont generalement bas, sauf dans les sols dèrives de roches basiques. La capacite de fixation du phosphore dans les sols du Sahel est generalement faible, et une reponse des cultures peut-etre obtenue par des doses relativement faibles d'engrai.

B. LES MOYENS TECHNIQUES

Il y a differentes voies pour arriver a l'utilisation optimale des ressources en sol. Elles sont toutes comprises entre deux extremes: d'une part, l'adaptation des plantes aux conditions edaphiques, d'autre part la modification complete des sols soit part l'irrigation, les engrais mineraux ou les pesticides.

1. Adaptation geographique

Les systemes de production traditionnels, qui comprennent des activites qui relevent des trois modes d'exploitation: agriculture, elevage et foret, se sont genèralement bien adaptes a la variabilite locale des sols. On peut reconnaître dans les paysages diverses sequences de sols, dont les proprietes sont souvent tres variees. En milieu rural coutumier, les familles de producteurs, tant que la pression demographique reste faible, ont disposé l'aire d'utilisation de chacun des composants du systeme en fonction des qualites ou des limitations

de chaque facette du paysage. Les exploitations plus intensives, peuvent beneficier de la source d'information detaillee qu'offrent les cartes d'association de sols, qui traduisent cette variabilité ordonnée des terres en fonction du paysage. Une planification doit tenir compte de l'existence de ces sequences de classe d'orientation culturale, si elle veut utiliser au maximum le potential des ressources naturelles. Les proportions entre les surfaces utilisees en agriculture, paturage et sylviculture doivent etre en equilibre avec les proportions des terres présentant ces vocations.

2. Adaptation varietale

Ce n'est que recemment que les methodes et les criteres de sélection des plantes ont pris en consideration les facteurs édaphiques qui limitant la production. En general, en station expérimentale, les lignees retenues etaient celles qui etaient les plus productives en conditions de sol optimales.

La tendance actuelle des selectionneurs est d'attacher plus d'importance au systeme racinaire des plantes en ce qui concerne son developpement en fonction de differentes contraintes, ou "stress", et d'isolar genetiquement des caracteres qui permettent aux nouvelles varietes de fournir des rendements maximum dans les conditions adverses. C'est evidemment une voie qui offre d'enormes possibilites, et dont l'effet, en milieu traditionnel, peut etre decisif, et automatique, puisqu'il court-circuit par les semences les goulots d'étranglement orees par le cloisonnement de l'agronomie en diverses disciplines.

Les contraintes considerees sont soit chimiques ou physiques Elles se rapportent tant au deficiences qu'aux toxicitiés. Pour le Sahel, les critères suivants seront sans doute d'importance: la résistance a la secheresse, la salinite, l'alcalinité. Les techniques de selection sont rapides, puisqu'elles sont basees sur le developpement racinaire après germination, ou sur la croissance de tissus collulaires en milieu artificiel. Elles peuvent porter sur un nombre très élevé de varietes. La recherche des caractères hereditaires qui definissent la resistance à la sécheresse considere plusieurs mecanismes d'adaptation: celui des varietes à cycle court qui en somme evite les periodes de manque d'eau; en second lieu le ralentissement de la croissance en période de sécheresse qui augmente la tolerence mais prolonge la periode culturale; finalement, les reactions des stomates en fonction de l'humidité qui diminuent la sensibilité des plantes face aux contraintes hydriques. Un certain nombre de lignées se défendent par un developpement rapide des racines en profondeur. Elles seront peu efficaces dans les sols qui présentent des horizons compacts à faible profondeur.

En ce qui concerne la sélection de varietées adaptees à la salinité et à l'alcalinité, de fortes différences à caractère héréditaire ont été constatées au sein d'une même espèce.

3. Amelioration des sols

L'intervention de l'Agronome sur les qualites du sol s'est principalement concentree sur la matiere organique

et l'apport d'engrais mineraux. Le rôle de la matière organique dans le maintien de la productivite des sols est double: elle agit principalement sur la structure et sur l'approvisionnement en azote. Dans les deux cas son action benefique n'est que de courte duree.

Le déclin de la fertilité après l'ouverture des champs pendant le cycle de culture est un phénomene qui n'est pas unique aux sols des tropiques. Les sols qui produisent de maniere continue des récoltes normales sans apports d'engrais mineraux sont rares, meme a l'echelle mondiale.

Si la densite d'occupation des terres augmente, l'intensification des methodes culturales et des mesures de protection des sols est inevitable. La technologie variera avec la disponibilite en eau, la disponibilite des terres et avec la nature du sol. Les conditions du marche definiront le degre d'intensification. Il n'est pas possible de donner des regles generales valables pour l'ensemble de l'Ouest Africain.

On s'efforce de coordonner l'apport d'engrais azotes avec les periodes de disponibilite en eau, avec l'epoque des besoins maximum des plantes, le volume du sol exploite par les racines. Le but vise est de dimunuer les pertes en azote par l'ixiviation et par le decapago des horizons superficiels par l'erosion.

L'apport de fumier, d'engrais verts, l'utilisation de la jachere sont des techniques qui reduisent les besoins en azote dans les systemes intensifs de production agricole. L'inclusion de legumineuses dans les rotations peut ameliorer

le bilan en azote, a condition que les autres facteurs de la fertilite ne soient pas limitants. On fait actuellement aux Etats-Unis, en collaboration avec des Instituts Agronomiques en zone tropicale, d'importantes recherches sur la fixation biologique de l'azote par les micro-organismes synbiotiques et non-symbiotiques.

Cet expose sur la fertilite des sols n'est certes pas exhaustif; on peut dependant rappeler que ce sont generalement les terres les plus productives dans les systemes traditionnels qui répondent le mieux aux méthodes intensives, et que c'est dans les parties les plus favorables des associations de sols que doivent se concentrer les efforts de fertilisation. On a parfois tendance a faire le contraire, en s'efforcant d'ameliorer des terres marginales; en termes monetaires c'est rarement productif.

C. TRANSFERTS DE TECHNOLOGIE

Il n'est pas etonnant, vu la complexite des problemes et le nombre de disciplines qui interviennent dans leur solution, qu'un effort de coordination soit nécessaire. Ce besoin existe dans le monde entier et n'est nullement limite aux problemes du développement rural en region tropical; il n'entre pas dans le cadre de cet expose de decrire les voies administratives que devraient suivre la vulgarisation.

On peut signaler deux points: le premier est celui de la cooperation plus etroite entre les selectionneurs des plantes et les types de contraintes édaphiques qui renferme un certain automatisme de transfert de technologie.

Le second point se rapporte a l'experience acquise aux Etats-Unis au courant des dix dernieres annees. La variabilité des sols y est plus grande et le nombre d'experimentateurs et de promoteurs du developpement rural plus important que dans beaucoup d'autres pays. Il a fallu faire de nombreux efforts pour diminuer la confusion dans les methodes d'investigation, et augmenter l'efficacite d'innombrables essais isoles. Un des moyens utilises est celui d'une taxonomie pedologique, et d'une nomenclature des sols stricte et rigoureuse, qui permettent a chacun de parler un même langage précis. Les définitions, des unites y sont suffisamment etroites pour qu'elle garantissent une uniformite adequate quant aux qualites des terres pour permettre un transfert de technologie, même sur de grandes distances (Soil Survey Staff, 1975). Il ne suffit pas de decrire les conditions du milieu, mais de les situer dans un cadre qui soit connu de tous. Le principe du transfert est simple: les memes résultats peuvent etre obtenus dans les sols d'une meme famille en appliquant les memes techniques. Il s'agit d'un transfert de technologie, non de factibilite. Cette dernière doit tenir compte egalment des facteurs autres que les ressources en sol. L'Ouest Africain se prête parfaitement a un tel systeme de transfert, vu la disposition des pays en zones ecologiques relativement uniformes. On pourrait donc suggérer qu'un effort soit fait dans l'elaboration des projets et dans l'experimentation agricole afin d'arriver à une terminologie comparable et de ce fait mettre une experience isolee a la disposition de tous. Il suffirait de mentionner dans les rapports techniques les noms des familles de sol utilisés.

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EXPERT CONSULTATION ON LAND EVALUATION STANDARDS

Rome, 25-28 October 1977

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113

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RECOMMENDATIONS GROUP

(Prof. A. Young)

1. We recommend that FAO produce a manual for Land Evalaution.

2. The manual should include information on the land requirements of individual crops and cultivars, within land utilization types.

3. Ecological and management requirements should be defined in such terms as to enable them to be matched with land qualities.

4. Requirements should be formulated in terms of optimal requirements and acceptable ranges of requirements.

5. For each individual crop or cultivar, the requirements considered should include the following:

   i. biology and phenology of the crop,
   ii. ecological requirements,
   iii. management requirements.

A preliminary review identified the following headings:

Ecological Requirements

1. Temperature Regime
2. Radiation Regime
3. Moisture Regime
4. Nutrient Requirements
5. Rooting medium requirements (including foothold)
6. Oxygen availability
7. Seedbed requirements
8. Absence of pests and diseases
   - toxicity
   - climatic hazard (e.g. frost)
   - environmental hazards
   - degradation

6. Similar examinations should be made of the requirements of other major land uses, including live stock and forestry.

7. The manual should include further amplification of the procedures followed in land evaluation. Aspects requiring amplification include matching procedures and processes, economic and social analysis. This will involve the commissioning of special studies. Attention should be given i.a. to the relation between inputs, land qualities, and outputs.

116

RECOMMENDATIONS GROUP II (Kowal)

We recommend that:

1. Draft guidelines for methodologies to be used in the production of empirical models for linking the physical environment with biomass and yield production should be prepared for circulation. The model should be suitable for use at different levels of sophistication.

2. Crop production experiments should always provide a link to a soil taxonomic system at the lowest possible level and preferably complete soil data particularly soil water storage data.

3. Crop and environment data banks relating both to standard management trial plots and to commercial farmers at different levels, are required to test and develop the empirical model. They should be established to include broad bioclimatic regions.

4. For rainfed arable LUTs, the major land qualities to be considered should be reduced to about ten, which can be dealt with at varied levels of sophistication. This should both assist in model development and improve agro-technological information transfer.

RECOMMENDATIONS GROUP III (Prof. Sys)

1. It is recommended that a manual for land evaluation be prepared with an outline of the procedures in land evaluation in order to make the framework operational. With regard to this we recommend:

   1.1 that such a manual include guidelines expressed in simple terms, even according to empirical methods, to reconvert land characteristics into land qualities;

   1.2 that a chapter be included on interpretation of land characteristics and crop requirements with regard to characteristics;

   1.3 that this manual include useful information on optimal and marginal crop requirements with regard to:

   - water availability,
   - nutrient availability,
   - foothold for roots,
   - oxygen;

   1.4 that terms and definitions of the framework, to be used in this manual, be improved or corrected:

   - clarification of particular approach,
   - land utilization type,
   - limitation.

2. We recommend further research in order to come to a better calculable relationship between characteristics and qualities.

3. The efforts devoted to presentation, in different ways, of the results of land evaluation should constitute an appreciable part of the total efforts required for the collection of data and their interpretation.

4. It is recommended that integrated maps be presented in addition to the land evaluation results for specific uses.

FAO/SIDA

REUNION TALLER

SOBRE

CONSERVACION DE SUELOS Y MANEJO DE TIERRAS

Lima, 3 - 15 octubre 1977

INVENTARIOS DE RECURSOS DE SUELOS EN AMERICA LATINA

por

Armand Van Wambeke

119

INVENTARIOS DE RECURSOS DE SUELOS EN AMERICA LATINA

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Esta contribucion consta de tres partes: la primera es una revision muy breve de los trabajos de levantamientos de suelos en America Latina; la segunda trata de los objetivos y los resultados preliminares de las investigaciones sobre la metodología de reconocimientos edafologicos que lleva a cabo el departamento de Agronomía de la Universidad de Cornell; la tercera sugiere actividades prioritarias para resolver algunos problemas relacionados con los objetivos de los inventarios de tierras.

I. Revision historica

Cinco universidades de los EE.UU. encargaron al Dr. Orvedal (1977) de compilar la bibliografía edafológica del tropico. Acaba de publicarse el volumen sobre América del Sur. Es evidente que esta obra no suministra una lista completa de todo lo que se ha publicado; sin embargo es una muestra que permite sacar algunas conclusiones. Es de hacer notar que al final de la publicacion se incluyeron algunas hojas en blanco que invitan a los lectores a hacer correcciones y mencionar publicaciones que no se incluyeron en esta bibliografía.

Un analisis del numero de trabajos en cuatro países seleccionados al azar, ha permitido establecer un diagrama de barras (fig. 1) que indica las frecuencias de estudios edafologicos que se publicaron cada año desde 1929. Se destacan de esos graficos tres observaciones mayores, sin que haya necesidad de realizar calculos estadísticos muy sofisticados.

La primera observacion es que el reconocimiento de suelos es una actividad que empezo a desarrollarse plenamente en America Latina hace 30 anos, y que por lo menos ha podido mantenerse a un nivel de intensidad considerable. Historicamente se pueden mencionar los siguientes acontecimientos como los de mayor importancia internacional:

(a) la publicacion del mapa de suelos del continente a 1:5,000,000 de la FAO/UNESCO (1974) y la elaboracion de un sistema de clasificación internacional para mapas a escala pequena.

(b) los trabajos de taxonomía de suelos por edafologos del Servicio de Conservación de Suelos de los EE.UU. que resultaron en la publicacion de la Taxonomía de Suelos (Soil Taxonomy 1975) en los cuales colaboraron muchos edafólogos de America Latina.

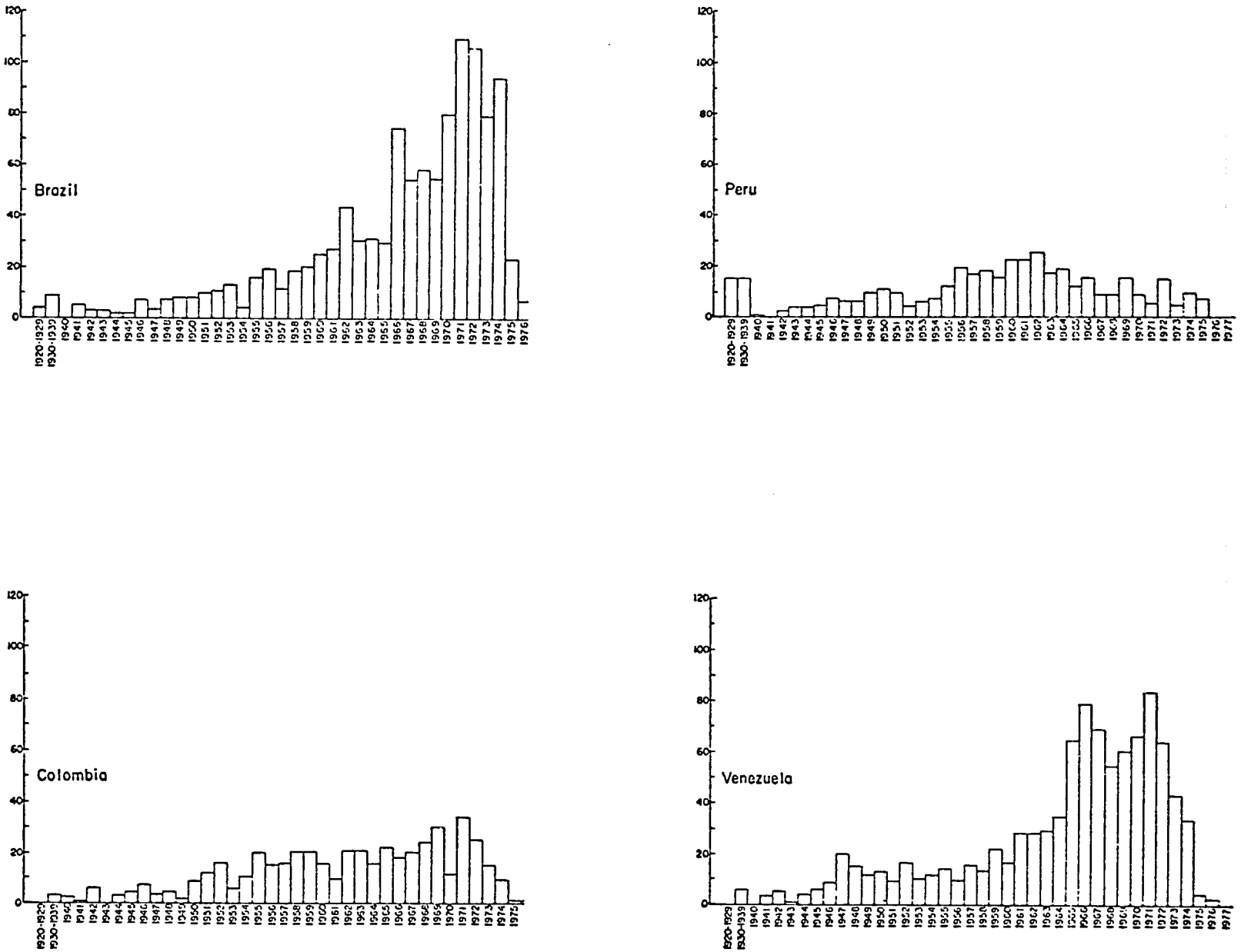


Figura 1. Numero de publicaciones sobre edafología en cuatro paises de America Latina.

Los dos sistemas permiten una nomenclatura consistente para designar suelos y, una vez cumplido el requisito de uniformidad de definiciones a una escala mundial, abren la posibilidad de transferencia de tecnologia. Los edafólogos insisten mucho en la necesidad de referirse, para cualquier tipo de trabajos de reconocimiento de suelos a un sistema de clasificacion uniforme que tenga valor universal en una region o en un país. Es un factor multiplicador de la eficiencia del levantamiento.

El principio de la transferencia de tecnología se basa en que las plantas tienen un comportamineto semejante bajo condiciones ecologicas comparables. Su aplicacion evita la repeticion de ensayos y experimentos agrícolas muy costosos de un país a otro, o de una region a otra.

(c) hubo muchas introducciones de nuevas tecnicas en las operaciones de levantamiento, tanto desde el punto de vista de la topografia, como de los metodos de observaciones de suelos, paisajes o caracteristicas del terreno relacionadas con suelos. Mencionaremos los sensores remotos desde aviones y satelites, los avances en la optica y en el poder de resolucion de las fotografias aereas.

La mayoria de las posibilidades que ofrecen estas nuevas tecnicas favorecieron principalmente la preparacion de mapas a pequena escala. No hubo aportes apreciables de los avances tecnicos para mejorar las condiciones de trabajo en el levantamiento de mapas de escala grande. Cuando se precisa informacion al nivel de la planta, para indicar el potencial de las tierras que trabaja el pequeño agricultor, el perfíl y el barreno parecen los únicos medios de observación.

La introduccion de las nuevas tecnicas resulto en la proliferacion de un sinfín de tipos de mapas, a varias escalas con leyendas y clasificaciones distintas; se creo una confusion tremenda entre clases de mapas y su utilidad. Por esta razon la distancia que ya existia entre los objetivos de los edafologos, agronomos, planificadores y economistas se alargo todavia mas. Es necesario que se tomen medidas para que se dicten normas que ajusten las caracteristicas de los levantamientos de suelos a las necesidades de la planificacion, para que haya un mejor entendimiento entre los que hacen y los que utilizan los mapas.

La segunda observacion que se desprende de los graficos es que en general el numero de trabajos ha ido en aumento. Esto es por una parte consecuencia del incremento del numero de proyectos de desarrollo en practicamente todos los paises, y por otra, del mayor interes y necesidad de conocer el potencial de las tierras antes de iniciar trabajos de asentamientos, colonizaciones o reforma agraria. En muchos casos son los bancos, tanto internacionales como nacionales, publicos o privados, que exigen una evaluacion previa de la tierra, los que indirectamente influyen sobre la demanda de inventarios de recursos de suelos. No hay datos sobre el numero de solicitudes de evaluacion de tierras que tienen su origen en la inquietud de los agricultores de conocer las aptitudes

de sus suelos.

Para finalizar el diagnostico en base a los graficos, se puede afirmar en tercer lugar que los informes edafologicos tardan cierto tiempo para llegar a su destino. El descenso que se nota en los histogramas durante los dos ultimos anos se debe probablemente a este fenómeno. Es un hecho universal que entre los trabajos de campo y la publicacion del informe muchas veces pasan mas de tres a cinco anos. Indudablemente esas demoras dañan mucho al proceso de planificacion que frecuentemente tiene que operar en condiciones de presiones, políticas, económicos o demográficas.

II. Investigaciones sobre la evaluacion y la metodología de los levantamientos de suelos.

El diagnostico anterior indica que hubo muchos esfuerzos para adelantar trabajos sobre los aspectos taxonomicos de las clasificaciones de suelos; al mismo tiempo las tecnicas modernas para promover la cartografía a pequeña escala se utilizaron con exito, especialmente en la selva Amazonica, y la Orinoquía.

El panorama de los varios tipos de inventarios de recursos de suelos se amplio tremendamente; sin embargo, no hay todavía en el mundo un estudio que describa detalladamente las limitaciones y las ventajes de cada una de las clases de mapas de suelos. Tampoco hay un ordenamiento, ni definiciones exactas de los tipos de inventarios. No existen metodos para evaluar mapas edafologicos o para seleccionar tipos de reconocimientos que sirvan objetivos específicos. No se ha preparado un manual que describa alternativas para operaciones de levantamientos de suelos bajo condiciones de trabajo limitantes.

No hay duda de que existe la necesidad de desarrollar esta metodolcgía. Los planificadores periodicamente piden evaluaciones de inventarios de suelos, solicitan medir la utilidad de los trabajos existentes y de establecer planes de operaciones para nuevos reconocimientos. Las implicaciones financieras son obvias cuando se considera que los costos de levantamiento son proporcionales al cuadrado de la escala. Doblar la escala significa aumentar los costos aproximadamente cuatro veces.

Por este motivo se establecio en el departamento de Agronomia de la Universidad de Cornell un grupo de trabajo para desarrollar esta metodologia. Se discuten a continuacion algunos criterios que se proponen para evaluar la utilidad de inventarios de suelos para ciertos objetivos:

(a) Escala del mapa

La escala es generalmente el primer criterio que se considera para identificar la categoria en la cual se ubica un mapa de suelos; sin embargo, no es un criterio suficiente; hay por ejemplo mapas a 1:10.000 que no muestran sino un solo límite entre dos suelos y que se identifican como mapas detallados. Se propone agregar un factor que indica cuantas

veces se puede reducir la escala de un mapa hasta llegar a un tamano minimo de las delineaciones. Este tamaño mínimo sería 0.4 cm^2. Mas pequenas las delineaciones, ya no se puede leer el mapa. Este factor se denomina el indice de reduccion maxima y corresponde a la raiz cuadrada de la relacion entre el promedio del tamano de las delineaciones actuales del mapa y el tamano mínimo (=0.4). La figura 2 es una ilustracion de este proceso de evaluacion. Por ejemplo un índice de dos indica que la escala de un mapa se puede reducir dos veces sin que pierda su utilidad (Eswaran, Forbes, Laker, 1977).

La combinacion de los dos criterios, escala actual e índice de reduccion, permite elaborar un primer esquema de clasificación que describe la densidad de líneas o la "textura" de un mapa. Se pueden reconocer varias clases, mutuamente exclusivas que se indican por símbolos dobles y llevan denominaciones específicas, por ejemplo: aA, mapa ultradetallado, de textura muy fina.

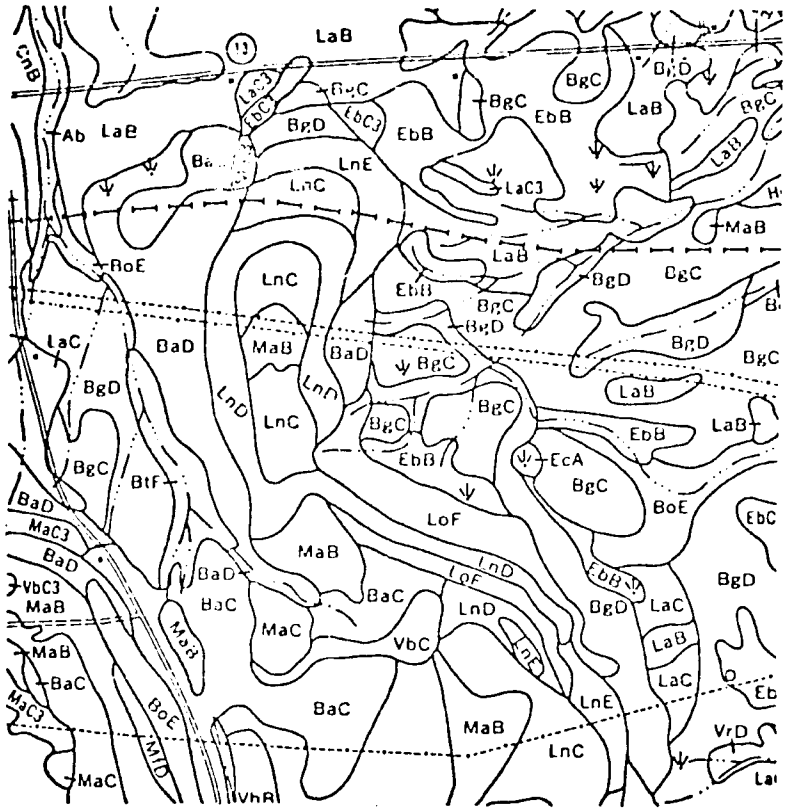
La clasificacion permite evaluar parte del esfuerzo que seria necesario para realizar los levantamientos de suelos; ademas los criterios impiden que se modifiquen escalas simplemente por amplificacion fotografica cambios en la clasificación.

Hay otros tipos de escalas edafologicas que sirven objetivos semejantes: una de esas es la escala virtual que propusieron los britanicos (Burrough et al.) 1971); o esta escala corresponde a una cierta densidad de puntos de observación por cm^2 del mapa. A una densidad de 2.5 observaciones por cm^2 la escala virtual y la escala de reduccion maxima son iguales; esto significa que hay un promedio de una observacion por cada delineacion. La relacion entre los dos tipos de escalas es uno de los índices que senala la importancia de las observaciones de campo durante las operaciones de levantamiento de suelos.

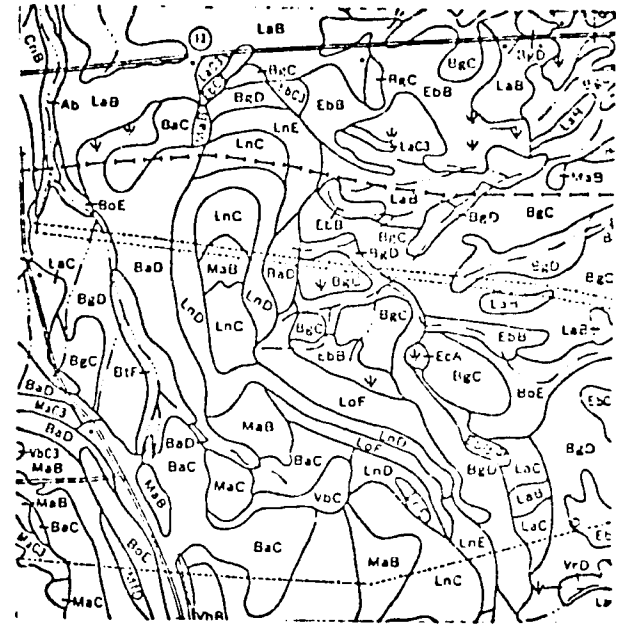
(b) Contenido de informacion

El tamano de las delineaciones es solamente un componente del conjunto de criterios que se utiliza para evaluar la utilidad de un mapa; este, por si solo no es suficiente y la informacion que procura la leyenda edafologica es de igual o de mayor importancia. Sin embargo, es mucho más dificil estimar el valor de la informacion que esta incluida en los nombres de las unidades cartograficas, que de medir tamanos de delineaciones.

Varios conceptos entran en los criterios que se utilizan para calificar la información que procura un mapa de suelos para objetivos específicos; se pueden enumerar algunos: pureza de las delineaciones (por ejemplo: consociaciones, asociaciones, grupos no diferenciados), enumeración de los factores limitantes para cultivos. Cada uno de los objetivos del uso de la tierra necesita una evaluacion distinta, que indica si la información es multivalente o restringida, tanto en lo que se refiere a los tipos de manejo, como a condiciones variables de



A



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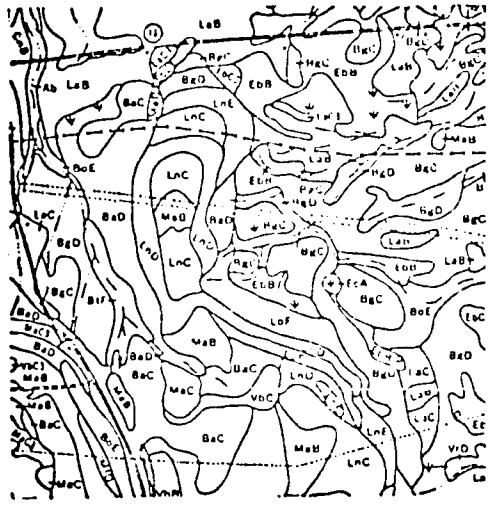

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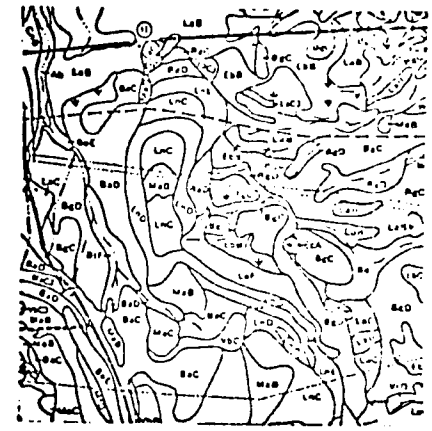

D

Figura 2. Ejemplo de reduccion de un mapa desde la escala original (A) hasta la escala mínima (D).

115

explotación en el futuro.

Cabe mencionar que las categorias de alto nivel en los sistemas taxonomicos existentes (orden, suborden, gran grupo) no son muy eficientes para indicar el contraste dentro de unidades cartográficas complejas, y generalmente hay que seleccionar propiedades de perfiles que se utilizan al nivel de la familia o de la serie para describir el grado de uniformidad de una unidad cartográfica.

Todavía no se han definido criterios adecuados para la evaluacion correcta del contenido de información de mapas edafólogicos.

(c) otros criterios

Hay otras caracteristicas que entran en la evaluacion de inventarios de suelos: pertenecen a esas la confiabilidad, la calidad del mapa topografico, la presentación de la leyenda y del informe. Son aspectos muy importantes, especialmente los que se relacionan al llamado "delivery system" que afecta por un factor de 0 a 1 la utilidad de los estudios al llegar a los usuarios. Los edafólogos se encuentran cerca del valor cero. No se hacen esfuerzos suficientes para poner los inventarios de suelos al alcance del agricultor.

El objetivo de la investigacion sobre clases de levantamientos de suelos es de mejorar la comprehension entre los planificadores del desarrollo agrícola y los edafólogos. Se ha mencionado la brecha cada día mayor entre las dos disciplinas.

Hay necesidad de ajustar la terminología entre los que piden información y los que la suministran. Se puede aclarar el problema con un ejemplo concreto que sería el de definir la escala de un mapa, adaptada a las necesidades de un determinado plan de desarrollo. Los administradores no encuentran normas que les permitan escoger la escala mas adecuada de un reconocimiento de suelos. Tampoco pueden evaluar el valor de los documentos ya disponibles.

Los planificadores tambien tienen su vocabulario de areas, a saber: (1) area a planificar; (2) area de trabajo; (3) area de igual comportamiento y (4) área de igual manejo. El area a planificar (vease figura 3) puede ser una provincia en la cual se tienen que asentar familias de agricultores en fondos a establecer (2) en un proyecto de colonizacion (2). Partes de estas haciendas recibirán un tratamiento igual (4) (por ejemplo sembrados en arroz). La respuesta de estos cultivos dependera de los factores limitantes de las tierras que definen las áreas de igual comportamiento (3).

Si el proyecto necesita ubicar y delimitar una de las 4 areas en un mapa de suelos, es el tamaño promedio del area mas pequena de las cuatro mencionadas el que define la escala del mapa, tomando como norma la delineacion minima de 0.4 cm^2. Por ejemplo si el area de decision mas

pequeno es el tamano de los fundos, por ejemplo 10 ha, se necesita por lo menos un mapa a escala de 1:50.000. Si no hay necesidad de delinear parcelas y el tamaño promedio de las áreas de igual comportamiento es de 684 ha, la escala mínimal del mapa debe ser mayor a 1:413.522. En la practica se tomaría 1:250,000. Este ejemplo es suficiente para ilustrar que la investigacion trata de definir criterios objetivos para escoger adecuadamente los tipos de inventarios de suelos que sirvan directamente proyectos específicos.

En el caso que hay que definir niveles de clasificacion e información, relaciones mucho mas complejas entran en consideración que no se pueden formular en estas pocas paginas; las personas interesadas se pueden referir a las memorias de un seminario que tuvo lugar en la Universidad de Cornell (1977).

III. Sugerencias para actividades futuras

Hay generalmente tres aspectos fundamentales dentro de los inventarios de suelos: la cartografía, la taxonomía, y la interpretación.

Muchas instituciones que han seguido el Manual de Levantamiento de Suelos (Soil Survey Manual, 1951) se enfrentan con problemas de correlacion de suelos en la incorporación de las unidades cartográficas en un sistema uniforme de clasificación. Sería conveniente establecer esos sistemas, al nivel nacional e incluso internacional. El procesamiento de datos por computadoras electrónicas puede acelerar estas operaciones.

En cuanto a clasificaciones edafológicas, el sistema de la FAO/UNESCO (1974) es muy general para servir de base a mapas de mayor escala. Por otra parte, la Taxonomia de Suelos (Soil Taxonomy, 1975) constituye un sistema mucho más detallado, más rígido. La aplicacion de ambos en el trópico enfrenta varios problemas. Ambos comparten dificultades en:

(a) La utilización de la saturacion de base para separar Ultisols y Alfisoles (Acrisoles y Luvisoles) en suelos con una capacidad de intercambio de cationes muy baja;

(b) El peso taxonómico que se da al horizonte argílico en perfiles formados en sedimentos fuertemente meteorizados.

(c) La evaluacion de los regímenes de humedad de los suelos, o de las fases climáticas.

Por otra parte, la aplicacion de la Taxonomia de Suelos (Soil Taxonomy, 1975) necesita un grupo de edafologos altamente entrenados para poder clasificar los perfiles en el sistema. La experiencia señala que solamente pocos perfiles que reciben un nombre de taxon son correctamente identificados al nivel del subgrupo. Es conveniente que se organicen cursos intensivos para adiestrar especialistas en esta rama.

La utilidad de los sistemas taxonomicos depende de las interpretaciones practicas. Las clasificaciones interpretativas son sistemas tecnicos que complementan la taxonomía, poniendo partes de ella en una perspectiva especifica relacionada con un sólo aspecto de la utilización de los suelos, o que solamente se refiere a una región. Las interpretaciones reducen el número de criterios, c el numero de clases o fases de manera que las agrupaciones se pueden entender facilmente. En la America Latina la mayoría de los países utilizan los conceptos de capacidad de uso y clases de aptitud, inspirandose en los trabajos realizados en los Estados Unidos (Klingebiel, 1961). En lo que se refiere a la fertilidad se puede mencionar el sistema que proponen Buol et al. (1974).

No hay todavía ninguna agrupacion tecnica que especificamente relacione los suelos con su susceptibilidad a la erosion, y a los métodos de conservación. Hay un area de investigacion abierto para la transferencia de esta tecnología en la cual puede contribuir la clasificacion de suelos.

Finalmente hay que mencionar que se necesitan mas trabajos experimentales para evaluar el potencial de las tierras. La experimentacion agrícola y la edafología necesariamente tienen que trabajar conjuntamente. Sería útil establecer una lista de estaciones experimentales que informe sobre los tipos de suelos y climas que se encuentran en sus areas geograficas. Esto ya podría ser un instrumento de intercambio de tecnologia estableciendose una red de información.

Las interpretaciones frecuentemente tienen que definir el potencial de la tierra bajo varios sistemas de manejo. Hay sin embargo una confusión tremenda en la palabra "potencial": para algunos no incluye los esfuerzos que se necesitan para realizarlo, para otros sí. Evidentemente los resultados prácticos que se obtienen utilizando una u otra definicion varian entre un fracaso o un exito completo. Se espera que esta reunion podra contribuir a formular una definicion que ayude a informar mejor a los planificadores en la toma de decisiones.

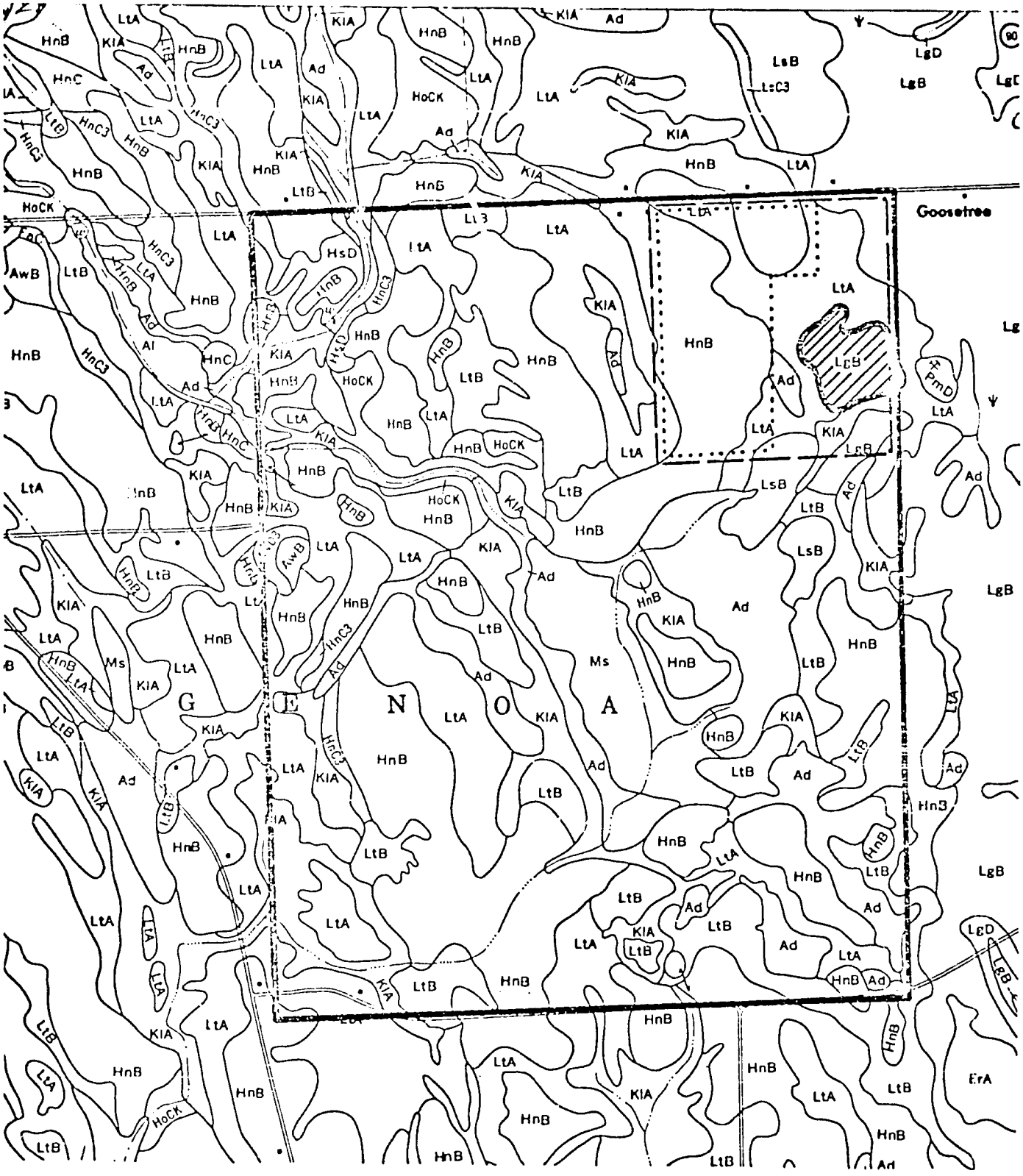

Figura 3. Ejemplo de áreas de decisión en la planificación del uso de la tierra.

área a planificar

área de trabajo

área de igual manejo

área de igual comportamiento

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REPORT ON REVIEW
OF
SOIL SURVEY INTERPRETATION ASPECTS
OF
COMPREHENSIVE RESOURCE INVENTORY EVALUATION SYSTEM (CRIES)
OF
U.S. DEPARTMENT OF AGRICULTURE
AGENCY FOR INTERNATIONAL DEVELOPMENT
AND
MICHIGAN STATE UNIVERSITY

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1978

The purpose of this writing is to summarize evaluations relating to soil survey interpretations in the Comprehensive Resource Inventory Evaluation System (CRIES) being developed by the U.S. Department of Agriculture, the Agency for International Development, and Michigan State University. This aspect of the evaluation was a part of the evaluation review conducted by J. F. Timmons (Iowa State University), T. G. Arscott (Ohio State University), E. E. Hardy (Cornell University), and G. W. Olson (Cornell University) during the week of 16-20 January 1978 in East Lansing, Michigan. This discussion is based on numerous unpublished documents provided to the evaluation team and the activities during the week of the review; a revised agenda of the presentations during the review week is attached to this write-up.

The CRIES project is a comprehensive resource inventory evaluation system for agriculture which is being implemented in the Dominican Republic, Nicaragua, and Costa Rica by an interdisciplinary team involving about 20 people (in the USA) and $2,000,000 over several years. Most of the work is done at Michigan State University, but considerable travel and some residency is apportioned in the countries involved. A general map of the Caribbean area is included with this report. Interdisciplinary cooperations are considerable, and joint appointments from the participating agencies contribute to the project as well as relationships with the relevant agencies within each country. Major emphasis is on the economics of the agricultural sector, but the disciplines of soil science, crop science, aerial photographic interpretation, computer science, botany, and resource development have contributed to the inventory base. Most of the work at the time of the evaluation had been done in the Dominican Republic, but similar efforts were starting in Nicaragua and Costa Rica.

Basically, the CRIES project is an assemblage of pre-existing resource inventory data and agricultural statistics into a planning format by which computer models can be formulated to assist in developmental decisions at the national level. Entry of the data into the computer is achieved for each country with a geographic cellular system consisting of cells of one square kilometer size. Information on soils and plant life zones is used to formulate areal Resource Production Units (RPU) to which all other agricultural statistical data are related as much as is possible. The RPU is essentially a regional planning area within the country to which resources can be allocated in developmental programs of the future in accord with the production potential and the social needs of the local population.

The soil information is the strongest and most basic data of the system--and the most important. Soil resources are the most important resources of any country, and those most likely to be damaged by mismanagement; thus insidious erosion can irreversibly harm the soils so that production is depressed in lowlands as well as highlands far into the future. Haiti is a good example to compare with the Dominican Republic in this regard. For this reason the soil input into CRIES is critical. Unfortunately, no fieldwork was budgeted for soil survey in the CRIES project (only about $10,000 was allowed for the soil data gathering). All soils data input into the system have been a standardization and generalization of the information already available in each country put together in an excellent fashion by Dr. Ellis G. Knox (Consultant for CRIES from Soil and Land Use Technology, Inc.). Each

country has different organizations for soil survey: the Dominican Republic has local soil surveys as well as soil surveys published by the Organization of American States and the Food and Agriculture Organization of the United Nations; Nicaragua has fairly good soil information for the Pacific side, but relatively little soil data for the Atlantic side; and Costa Rica has a great variety of different kinds of soil surveys done by numerous agencies, institutions, and universities. General soil information on all of the countries was available from the World Soil Geography Unit of the Soil Conservation Service of the U.S. Department of Agriculture.

To illustrate the soil information derived for CRIES by Dr. Ellis G. Knox, descriptions for several of the soil map units and a soil map of the Dominican Republic are attached to this report. Symbols of the World Soil Map of the World Soil Geography Unit of the Soil Conservation Service were used along with the nomenclature of Soil Taxonomy (Soil Survey Staff, 1975). The soil map unit symbols have three parts: (1) the symbol of the dominant soils, (2) the numerator of a fraction that shows the geomorphic landform, and (3) the denominator of a fraction that indicates the soil parent material or the material underlying the soil. The landforms of the Dominican Republic are dissected terraces (DT), fans at bases of mountains (F), floodplains (FP), karst topography (K), level plains (L), mountains (M), rolling and hilly terrain (RH), steep hills (S), terraces (T), undulating plains (U), undulating and rolling plains (UR), and swamps (WS). The underlying materials are unconsolidated alluvium (A), unconsolidated lacustrine alluvium (LA), limestone (LS), limestone and shale (LSS), unconsolidated marine sediments (M), mixed acid and basic igneous and metamorphic rocks (RB), and volcanic tuff (T). Double symbols indicate associations of groups of soils. Thus DOAa F/A - DOAa RH/LS has mostly variable kinds of Typic Camborthids on fans and uplands underlain by alluvium and limestone. Similarly the DOAa RH/LSS soil map unit has predominately Typic Camborthids on erosional rolling and hilly uplands over limestone and shale with slopes mostly less than 30%; the EOHj L/LA soil map unit has mostly Ustic Torriorthents on level plains over lacustrine and alluvial materials; the EOUdk UR/LS soil map unit has mostly Skeletal Lithic Ustorthents on undulating and rolling plains over limestone; the ITYf S/T soil map unit has mostly Lithic Dystropepts on erosional hills over tuff with slopes generally steeper than 30%; and the ITYs M/RB soil map unit has Shallow Typic Dystropepts on mountains over igneous and metamorphic rocks mostly steeper than 30%. Each soil map unit description includes also estimated soil properties and special features of the dominant soils.

Plant life zones were also used according to the delineations made by Leslie R. Holdridge (Holdridge, 1969). These map units show the relationships existing between climate and other environmental factors by quantitatively relating biotemperature, precipitation, and humidity. Since the soil map units also contain elements of temperature and moisture regimes of soils, the plant life zones generally had similar boundaries as geomorphic groupings of soil map units--but in a few cases the boundaries of the plant life zones were different from the soil boundaries. The general soil map of the Dominican Republic had about 40 units, and the plant life zones numbered less than 10.

Resource Production Units (RPU) were formulated from the general soil map and the plant life zones; the RPU map and descriptions of several of the

RPU areas for the Dominican Republic are included with this report. The Resource Production Unit (RPU) is defined as a unit of land with components sufficiently homogeneous with respect to agrophysical factors of soil, climate, and water resources to be depicted by one or a few unique estimates of agricultural factors such as crop adaptability and input-output coefficients. Obviously, each RPU has a set of related soils (which may or may not be highly contrasting) in a similar geomorphic setting; the soil contrast within each RPU is unique and different from that in each of the other RPU area map separations. The attached RPU descriptions for units 2, 10, and 17 excellently illustrate the type of production areas in the Dominican Republic. The mountain areas (RPU #2) have soils that are extremely variable, but the soils have relatively low agricultural potential due to the predominate steep slopes. The estuarys and tidal flats (RPU #10) are wet and saline in places. The RPU #17 has good soils in about 90% of these areas on terraces, footslopes, and pediments over water-deposited sediments--these areas are some of the most potentially productive in the Dominican Republic and are already producing a wide variety of crops.

In the Comprehensive Resource Inventory Evaluation System (CRIES), the Resource Production Unit (RPU) is the basic area of aggregation of CRIES data within the country. Thus the square kilometer grid cells within each RPU area can be evaluated in terms of the data entered into the computer for each cell; computer analyses can be used to illustrate the differences between each RPU and the variability within each RPU in terms of agricultural production functions. Generally the past work described to the reviewers in oral and written form was judged to be good; several areas of opportunity in soil survey interpretations, however, are being neglected due to understaffing of pedologists (soil scientists)--not even a single full-time pedologist is presently working with the large staff of CRIES economists at Michigan State University.

The neglected area of soil survey interpretations of the CRIES project involves use of specific soils and specific soil characteristics in determination of present and potential yields under different management systems. Presently the CRIES staff is using economic census data and local economic survey data to make crop yield estimates and predictions; although truly heroic efforts have been made to interpret these data, they are often conflicting, inconsistent, and appear to be faulty at least in some cases (e.g. for yucca) in the minds of the reviewers of the project. From the perspective of the soils (Olson, 1973), it would be better for the CRIES staff to rank the soils for their productivity based on the soil characteristics. Then high and low yield values for each crop for each soil could be assigned from experiment station results, data of experimental agronomy trials on farmer fields, and consultations with local agronomists and soil scientists in the Dominican Republic and the other countries. With data on production for even a few key soils, estimates of yields could be made for all of the soils from the rankings based on the soil properties. Using this procedure, reliable estimates for present and potential yields of all crops on all soils under different management conditions could be made with minimal effort and maximum benefit to the CRIES computer modeling process. The yield of each soil could be assigned its relative proportionate importance to each square kilometer cell and to each Resource Production Unit (RPU) based on the soil map unit descriptions and the RPU area descriptions. This procedure would relate the economic production output statistics back to the

specific soil characteristics from which the agricultural production was derived in the first place. These procedures are used in all of the recent hundreds of published soil survey reports of the Cooperative Soil Survey in the United States; CRIES staff should carefully study these soil survey reports particularly for tropical areas including Hawaii, Puerto Rico, and the Virgin Islands (Rivera et al., 1970).

Due to the faulty local economic data, CRIES staff should concentrate on accumulation of as much data of a primary nature as is possible to relate to soil map units and resource production units. Thus aerial photographic interpretation and satellite imagery can be used very effectively to map land use and crop acreages to be related to soils. These primary data are much more reliable than revised secondary census data of questionable origin. At the same time, statistical samplings and ground truth should be formulated to improve future statistical gatherings. The computer and the grid system of CRIES affords marvelous opportunities to relate all kinds of land use data and production functions to the soils upon which land use and agricultural production are based.

Soil survey interpretations should be developed and expanded in the CRIES project as far as is possible, particularly in Nicaragua and Costa Rica where modeling work is just getting started (at the time of the evaluation review). The CRIES grid cell computer model gives many excellent opportunities to outline alternative production programs based on the hard primary soils data. Ratings should be made of the soils for suitabilities, capabilities, limitations, and hazards for alternative cropping patterns--based on the soil characteristics. Grid cell maps can readily be printed by the computer (based on soil information) to show areas best and worst suited for corn, beans, coconuts, sugar cane, yucca, rice, tobacco, coffee, bananas, and other crops--and to show responses of these soil areas to irrigation, fertilization, interplanting, sequential cropping, and other possible feasible management situations. The CRIES project will only be effective through the outputs of valid tabular data and maps, and these outputs will be more accurate and reliable if based on the hard primary data of the soil survey inputs.

The evaluation team was very favorably impressed with the quality and working relationships of the CRIES staff as it was observed during the evaluation. Some problems are being encountered due to reorganizations and administration and lack of certainty of continuity of the project, but the personal contacts are good and moral is high. If the project could be given more separate identity and continuity of support, efficiency of the work could be increased considerably. The techniques of computer modeling and grid cell entry of data have been well established and proven through experiences of many workers on other projects in other areas.

Aspects of training and follow-up in use of CRIES data are extremely important if the system is to be effectively continued by local personnel in the countries involved. It appeared to the evaluation team that all of the potential users of the CRIES analyses had not been identified, and that adequate provisions for training of large numbers of local people in the workings of the system had not been provided for--partly this appeared to be due to constraints of the AID (Agency for International Development) contract

which assumes that training programs will be initiated and handled administratively by the AID program within each country. At any rate, training components of all aspects of the CRIES project should be strengthened and broadened as much as is possible within each country. The CRIES material would also adapt itself excellently to a wider audience through teachings in regional centers; this reviewer has recently had very beneficial experiences (Olson, 1975, 1977) of teaching soil survey interpretations at regional centers of CIDIAT (Centro Interamericano de Desarrollo Integral de Aguas y Tierras) for Latin America (at University of the Andes in Merida, Venezuela) and at SEARCA (Southeast Asian Regional Center for Graduate Study and Research in Agriculture) for Southeast Asia (at University of the Philippines at Los Banos)--these regional teaching centers as well as others would likely be extremely receptive to offerings of short courses and extended courses relating to CRIES project materials.

The CRIES project concept is excellent and has a great deal of potential for improvement of decision-making on regional, national, and international levels. As Lester Brown (Brown, 1977) has excellently stated, policy makers need to redefine national security to emphasize the long term items that are <u>really</u> important--particularly relating to the resource base of a country. Thus soil erosion destroying the productive potentials in Latin America will have serious consequences to the security of the United States in the decades and centuries ahead--even if soil erosion is adequately controlled in the United States. Resource problems are even of great importance in the short run, as the refugees and illegal immigrants (due to overpopulation on an eroding soil resource base) into the United States from Haiti and Mexico well illustrate. In a world of shrinking and degrading land resources, the well-being of every individual in the United States is linked more closely than is realized to the poverty of the less wealthy nations. The CRIES project is one of the few noteworthy contributions toward understanding the partial and total picture of the problem, so that more rational decisions based on properly organized facts can be made in the future.

In summary, the reviewers are greatly pleased with the progress of the CRIES effort. From a soils perspective, the CRIES project is understaffed with respect to pedologists--and the reliability of the economic data could be greatly strengthened by increased emphasis of primary soils data and relationships of land use and production to those basic soils characteristics. At least one (and preferably more) pedologist should be assigned full-time to work with the CRIES staff at Michigan State University to relate yield data to soils and to rate soils for crop production. Ideally, also, at least one pedologist (and preferably more) should be assigned full-time to work with and train the pedologists and agronomists in the involved countries. This reviewer is truly amazed at the amount of soils input and output that has been accomplished thus far in the CRIES project with such a meager amount of budget input.

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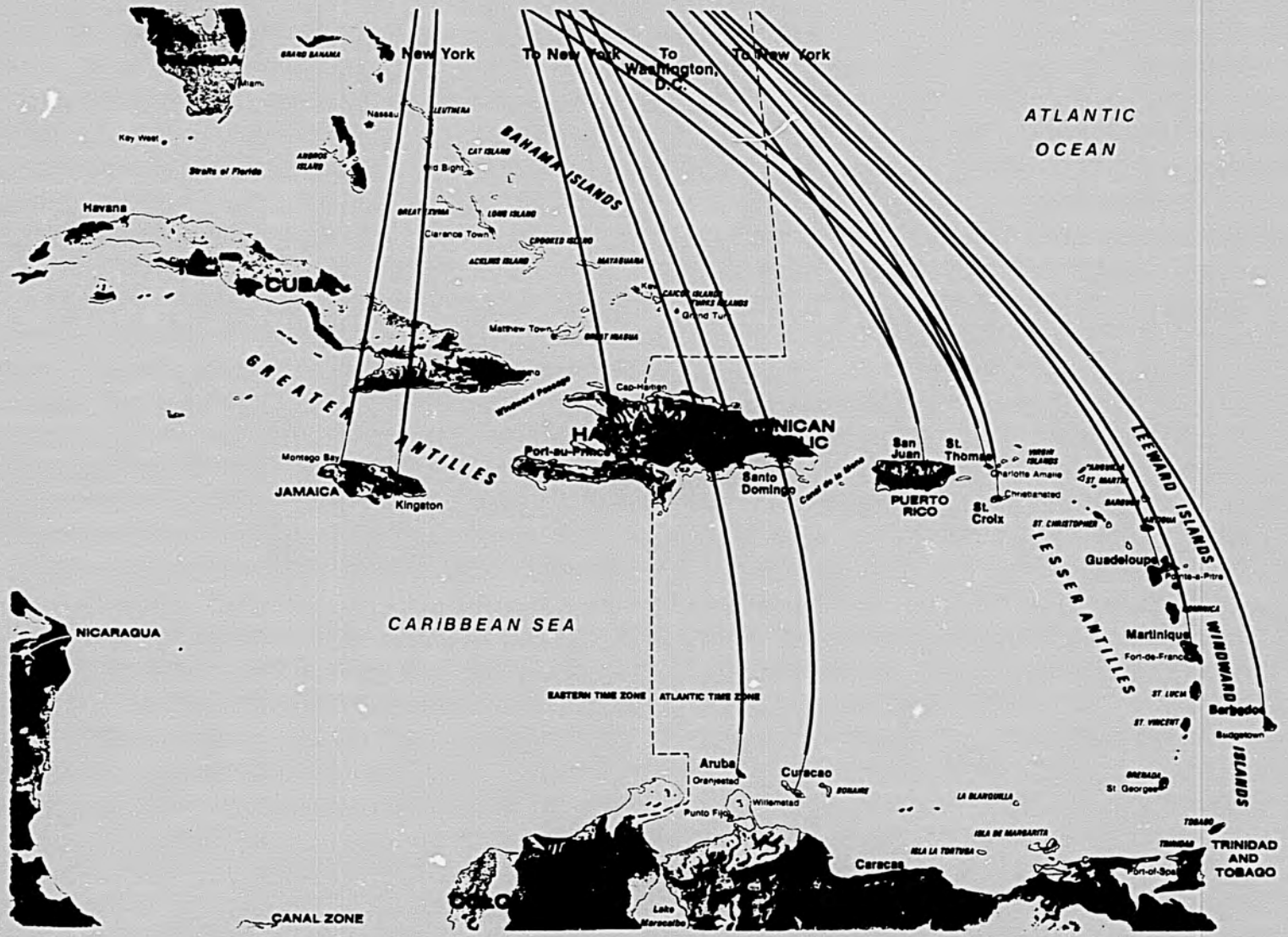

To New York
To New York
To Washington, D.C.
To New York
ATLANTIC OCEAN
BAHAMA ISLANDS
GREATER ANTILLES
LESSER ANTILLES
LEEWARD ISLANDS
WINDWARD ISLANDS
CARIBBEAN SEA
Havana
CUBA
JAMAICA
Kingston
Montego Bay
Port-au-Prince
Santo Domingo
San Juan
PUERTO RICO
St. Thomas
St. Croix
Guadeloupe
Martinique
Barbados
Bridgetown
TRINIDAD AND TOBAGO
Port-of-Spain
Caracas
Aruba
Curacao
NICARAGUA
CANAL ZONE
EASTERN TIME ZONE
ATLANTIC TIME ZONE

138

REVISED AGENDA
AID/TAB & USDA
CRIES EVALUATION
January 16-19, 1978

Monday, January 16

6:30 p.m. - Separate Dinner Meetings
1. Evaluation team
   -to get acquainted and discuss organizational arrangements and procedures
2. CRIES Staff and others
   -general orientation, discussion, etc.

8:00 p.m. - Executive Session
A short session of the Evaluation team, MSU Department Chairmen, AID Representative, ESCS Deputy administrator and study leader to finalize procedures and agenda

Tuesday, January 17

8:30-8:45 a.m	-Opening Remarks and Introductions,	Putman Riley Vlasin
8:45-9:15 a.m.	-Evaluation team remarks -AID, ESCS/DC and MSU. Remarks on Evaluation	Timmons Suttor Schertz Riley/Vlasin
9:15-9:45 a.m.	-Introduction of CRIES	Putman
9:45-10:15 am	-Discussion	
10:15-10:45 am	-Land Base Methodology Soil Survey Plant Life Zones RPUs	 Ackerson/Knox Atchley Group
10:45-11:30 am	-Discussion	
11:30-1:00 p.m.	LUNCH	
1:00-1:30 p.m.	-The Geographic Data File	Tilmann
1:30-2:00 p.m.	-Discussion	
2:00-2:30 p.m.	-Data Sources, Country totals, and Land Use	Harrington
2:30-2:50 p.m.	-Discussion	
2:50-3:00 p.m.	-Remote Sensing Tests	Tilmann

3:00-3:10 p.m.-Discussion

3.10-3:30 p.m.-Production techniques, yields and Costs-- First Generation System — Johnson

3:30-4:00 p.m.-Discussion

4:00-4:30 p.m.-Production Techniques, Yields, New Crops and Transferability — Duke

4:30-5:00 p.m.-Discussion

6:00-7:30 p.m.-Attitude calibration — Putman's house

8:00 p.m. -Group Dinner

Wednesday, January 18

8:30-9:00 a.m.-CRIES Analytical System Overall Philosophy and the CRIES Analytical System — Putman

9:00-9:30 a.m.-Discussion

9:30-9:45 a.m.-The Working System and Haverly — Lodwick

9:45-10:00 am - Discussion

10:00-10:30 am -Future of CRIES — Putman

10:30-11:30 am -Wrap up of Evaluation team Questions — Timmons

11:30-1:00 p.m.-LUNCH

1:00-4:30 p.m.-Separate Sessions
1. Evaluation team
2. CRIES staff

Thursday, January 19

8:30-11:00 am -Joint meeting(s) of CRIES Staff and Evaluation Team, together or in subject matter groups.

11:00-11:30 am -Preliminary Reflections of Evaluation TEam

11:30-1:00 p.m.-LUNCH

1:00 p.m. - Plane time
Separate Sessions
1. Evaluation Team session to plan evaluation report

2. CRIES staff session to plan CRIES evaluation report of CRIES

Symbol: DOAa F/A - DOAa RH/LS Typic Camborthids

Composition: 30-60% Typic Camborthids on fans.
10-40% Typic Camborthids on uplands.

Physiography: Pediments, alluvial fans, and modified coastal plain and estuarine terraces over alluvium with low hills and rolling uplands over limestone scattered throughout.

The Camborthids may range to Haplargids at one extreme or to Torriorthents at the other. The moisture regime is considered to be marginally aridic to ustic. The soils are identified here as typic because the ustropeptic subgroup has not been recognized. The soils are isohyperthermic and most are coarse-loamy or loamy-skeletal. The mean annual precipitation ranges from 400 to 900 mm, with one or two maxima in the May through October period. The mean annual temperature ranges from 26 to 29°C. The native vegetation was desert shrub. Susceptibility to erosion and the potential for use of machinery vary with slope of the various components. Some of the soils have rock fragments that would make use of machinery difficult. These soils are too dry for cropping without irrigation. Sources of water are not apparent. There has been essentially no agricultural use of the area. These soils previously were mapped by OAS in 1967 in units 136, 142, 138, 137, 139, and 132.

ESTIMATED SOIL PROPERTIES AND SPECIAL FEATURES

	Typic Camborthids	Typic Camborthids
% Distribution	30-60%	10-40%
Slope	3-8%	8-30%
Depth to bedrock	1-5 m	0.2-1 m
Soil texture	medium medium	
Coarse fragments	pebbly	cobbly
Permeability	moderate	moderate
Reaction	moderately alkaline	moderately alkaline
Salinity	nonsaline	nonsaline
Available water capacity	moderate	low
Flooding	none	none
Soil drainage class	well drained	somewhat excessively drained
Base saturation	calcareous	calcareous

Symbol: DOAa RH/LSS Typic Camborthids

Composition: 40-70% Typic Camborthids.

Physiography: Erosional rolling and hilly uplands over limestone and shale with slopes mostly less than 30%.

The Camborthids may range to Haplargid at one extreme or to Torriorthents at the other. The soils are identified here as typic because the ustropeptic subgroup has not been recognized. The underlying materials include limestone, gypsum, and clayey schist. The soils are mostly coarse-loamy, ranging to fine-loamy and loamy-skeletal. Some may be shallow to paralithic contact. These soils are in a delineation that borders a delineation of Eutropepts. The transition of ustic soils is probably very narrow on the steep mountain front. All soils are isohyperthermic. The mean annual precipitation ranges from 400 to 900 mm, with one or two maxima in the May through October period. The mean annual temperature is from 26 to 28°C. Steep slopes make these soils susceptible to erosion and limit the degree of mechanization of farming operations. Incised drainageways with slopes steeper than 30% restrict movement through the delineation. The soils are too dry for cropping without irrigation. Sources of water are not apparent and slopes are too steep for efficient application of water. Some of the soils would be too high in gypsum or more soluble salts for best crop growth. There has been essentially no agricultural use of these soils. They were mapped previously by OAS in 1967 in unit 132.

ESTIMATED SOIL PROPERTIES AND SPECIAL FEATURES

	Typic Camborthids
% Distribution	40-70%
Slope	8-30%
Depth to bedrock	0.5-1 m
Soil texture	mod. fine
Coarse fragments	stony
Permeability	mod. slow
Reaction	moderately alkaline
Salinity	nonsaline
Available water capacity	low
Flooding	none
Soil drainage class	somewhat excessively drained
Base saturation	calcareous

Symbol: EOHj L/LA Ustic Torriorthents

Composition: 30-60% Ustic Torriorthents.
10-40% Typic Tropaquents.

Physiography: Level plains over lacustrine and alluvial materials.

The Torriorthents probably range to Typic (Ustropeptic) Camborthids. The wetter soils may not show the colors typical of Aquents. Halaquepts and Salorthids may be present. This unit is in a desert basin in an orogenic trench. Much of the area is below sea level. Marine materials, including sandy beach deposits, have been modified or buried by lacustrine and alluvial materials since isolation of the area from the sea. For some of the soils, high water tables result from irrigation in surrounding areas without sufficient drainage. The soils are isohyperthermic. They are coarse-loamy or in other loamy particle size classes. The mean annual precipitation ranges from 400 to 900 mm, with one or two maxima in the May through October period. The mean annual temperature ranges from 26 to 29°C. The native vegetation was desert shrub and salt barrens. These soils are susceptible to deterioration through accumulations of salts and sodium resulting from poor irrigation practices. They are well suited for a high degree of mechanization. The well drained, nonsaline soils are well suited for crop growth and production. Sugarcane and plantains are the major crops. These soils previously were mapped by OAS in 1967 in unit 134-135.

ESTIMATED SOIL PROPERTIES AND SPECIAL FEATURES

	Ustic Torriorthents	Typic Tropaquents
% Distribution	30-60%	10-40%
Slope	0-3%	0-3%
Depth to bedrock	>5 m	>5 m
Soil texture	medium	medium
Coarse fragments	nonstony	nonstony
Permeability	moderate	moderate
Reaction	moderately alkaline	moderately alkaline
Salinity	slightly saline	moderately saline
Available water capacity	moderate	moderate
Flooding	rare	occasional
Soil drainage class	well drained	somewhat poorly drained
Base saturation	calcareous	calcareous

Symbol: EOUdk UR/LS Skeletal Lithic Ustorthents

Composition: 40-70% Skeletal Lithic Ustorthents.

Physiography: Undulating and rolling plains over limestone.

The soils are over corraline material with numerous fractures and holes that can be interpreted to be either fractured bedrock or skeletal or fragmental material. The soil-coral interface is highly irregular and the small-scale soil variability is very high. The soils are iso-hyperthermic and most are in fine or very fine particle size classes. Some of the deeper soils are considered to be lateritic and are thought to be Oxisols by the Dominican soil scientists. Observation of one profile from an excavation in Santo Domingo showed greater plasticity and stickiness than expected for an oxic horizon. Classification as Ustropepts seems more likely. The mean annual precipitation ranges from 1,000 to 1,400 mm, with a distinct first-quarter dry season. The mean annual temperature ranges from 26 to 27°C. The native vegetation was probably a low, shrubby forest. The land surface is rough and irregular, apparently slightly modified from the original coral reef surfaces. Even with hand labor, cropping is almost impossible. Outcrops and shallow bedrock, rock fragments, or both offer extreme limitations for use of machinery. Limitations in soil moisture supply restrict the possibilities for adapted tree crops (possibly papaya). These soils have had very little agricultural use. They were mapped previously by OAS in 1967 in unit 50-53.

ESTIMATED SOIL PROPERTIES AND SPECIAL FEATURES

	Skeletal Lithic Ustorthents
% Distribution	40-70%
Slope	3-15%
Depth to bedrock	0.1-0.5 m
Soil texture	fine
Coarse fragments	extremely stony
Permeability	slow
Reaction	moderately alkaline
Salinity	nonsaline
Available water capacity	very low
Flooding	none
Soil drainage class	somewhat excessively drained
Base saturation	>50%

Symbol: ITYf S/T Lithic Dystropepts

Composition: 30-60% Lithic Dystropepts.
10-40% Typic Dystropepts.

Physiography: Erosional hills over tuff with slopes mostly steeper than 30%.

The shallow component includes Lithic Troporthents and Typic Dystropepts shallow to paralithic contact in addition to Lithic Dystropepts. The deeper component may include some Typic Tropudults. The soils are isohyperthermic. Probably most are in the fine particle size class. The mean annual precipitation ranges from 2,000 to 2,300 mm, with a very milk first-quarter dry season. The mean annual temperature ranges from 24 to 26°C. The native vegetation was forest. The steep slopes make the soils susceptible to erosion and limit farming operations to mostly hand labor. Suitability of the soils for plant growth is limited by depth and acidity. Part of the area is used for pasture. Small areas are used for food crops with hand labor. These soils were previously mapped by OAS in 1967 in units 104, 9, 44-46, and 44-45.

ESTIMATED SOIL PROPERTIES AND SPECIAL FEATURES

	Lithic Dystropepts	Typic Dystropepts
% Distribution	30-60%	10-40%
Slope	>30%	8-30%
Depth to bedrock	0.2-0.5 m	0.5-2 m
Soil texture	mod. fine	mod. fine
Coarse fragments	stony	stony
Permeability	mod. slow	mod. slow
Reaction	strongly acid	strongly acid
Salinity	nonsaline	nonsaline
Available water capacity	very low	low
Flooding	none	none
Soil drainage class	well drained	well drained
Base saturation	<50%	<50%

Symbol: ITYs M/RB Shallow Typic Dystropepts

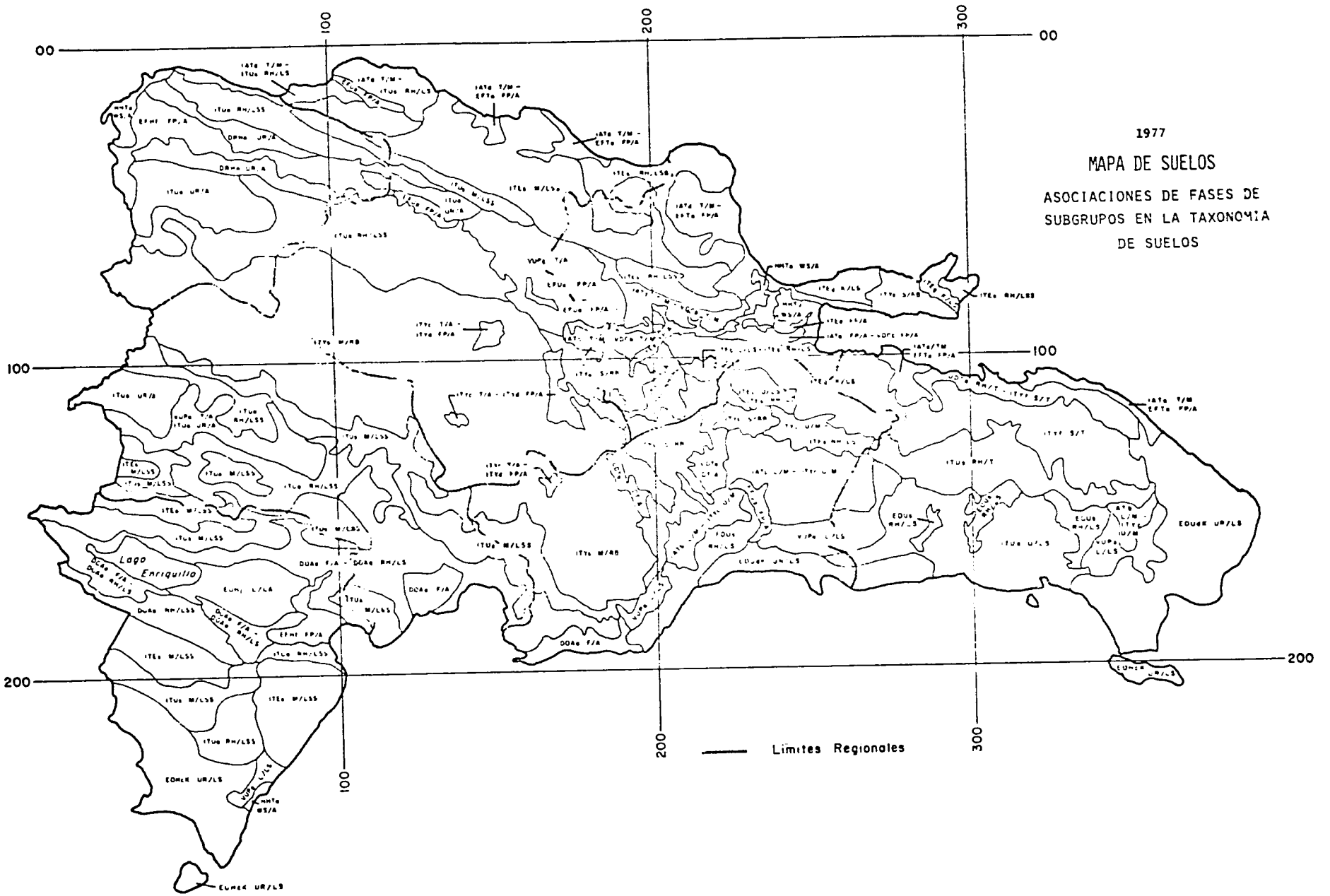
Composition: 30-60% Typic Dystropepts shallow to paralithic contact.
10-40% Typic Dystropepts deeper than 50 cm.

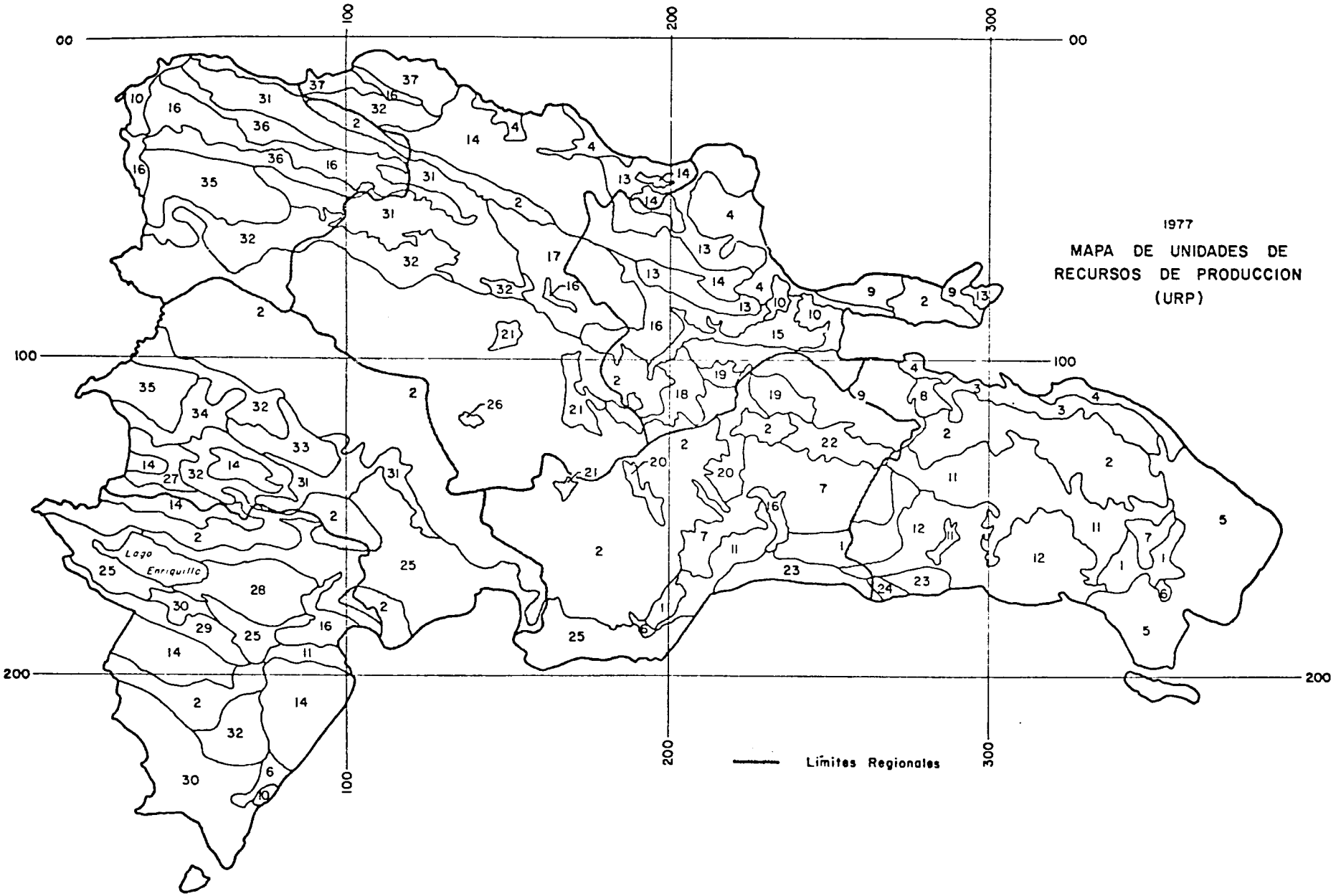
Physiography: Mountains over igneous and metamorphic rocks with mostly steeper than 30%.

The shallow component includes Lithic Dystropepts and Troporthents shallow to paralithic or lithic contact. The soils are mostly isohyperthermic below 1,200 m elevation and mostly isothermic above that elevation. Fine-loamy and fine soils are dominant. There is a wide range of igneous and metamorphic rocks, including serpentine near Bonao and La Vega. The mean annual precipitation ranges from 1,800 to 2,500 mm, with a mild first-quarter dry season. The mean annual temperature ranges widely with elevation from about 15 to 25°C. The native vegetation was forest. Slope makes these soils susceptible to erosion and restricts farming methods to hand labor almost exclusively. Some soils have rock fragments that interfere with farming operations. Acidity and depth to rock limit the suitability of these soils for crop growth. Some plots are used for coffee and food crops with hand labor. These soils were previously mapped by OAS in 1967 in units 104, 146, 152-153, and 46.

ESTIMATED SOIL PROPERTIES AND SPECIAL FEATURES

	Typic Dystropepts	Typic Dystropepts
% Distribution	30-60%	10-40%
Slope	>30%	15-30%
Depth to bedrock	0.1-0.5 m	0.5-2 m
Soil texture	mod. fine	mod. fine
Coarse fragments	stony	stony
Permeability	mod. slow	mod. slow
Reaction	strongly acid	strongly acid
Salinity	nonsaline	nonsaline
Available water capacity	very low	low
Flooding	none	none
Soil drainage class	well drained	well drained
Base saturation	<50%	<50%


1977
MAPA DE SUELOS
ASOCIACIONES DE FASES DE
SUBGRUPOS EN LA TAXONOMIA
DE SUELOS
Lago
Enriquillo
Limites Regionales
00
100
200
300


1977
MAPA DE UNIDADES DE
RECURSOS DE PRODUCCION
(URP)
Límites Regionales
Lago Enriquillo
00
100
200
300

RPU #2

RPU #2 is the dryer portion of the high mountain areas of the country. It includes the high mountains of the Cordillera Central, Sierra de Neiba, and Cordillera Septentrional of the western two-thirds of the country plus the smaller range in the east. As a unit, the RPU is the largest (1,431,400 hectares) and most heterogeneous of all RPUs. The RPU ranges from high agricultural productivity in the small valleys to barren on the mountain peaks. Hence, it must be recognized as a conglomerate of soils, unmappable at the scale used in this study, but possessing little agricultural crop production potential except for the valleys. Many small hillside and ridge plots are being farmed by hand with moderately low results. This trend seems to be increasing with the threat of erosion and watershed deterioration severe.

The area is characterized as steep uplands and mountains with shallow, rocky soils generally unsuited for agriculture.

The climate is moist to wet, with average annual precipitation ranging from 900 to 2,400 millimeters. The first quarter dry season ranges from very mild to distinct. Generally, rainfall and severity of dry season in the RPU depends upon altitude within areas and ranges from the dryest in the Sierra de Neiba to the wettest in the Cordillera Central. The mean annual temperature ranges from 20 to 26°C in areas below 1,200 meters of elevation with temperatures of 15 to 22°C at higher elevation. Temperatures are uniform throughout the year with frosts common at the higher elevations.

The natural vegetation includes pine forests, with broadleaf forests in cloud zones, common to moist, wet, and rain-forest life zones of the sub-tropical to wet forest of the premontaine latitudinal zones. Small ridges with very high rainfall contain rain forest vegetation. The RPU is generally not productive due to extremely steep slopes and shallow, rocky soils.

RPU #2 consists of four soil map units identified and described in Appendix I as follows:

Map Symbol	Code	Proportion of RPU	Dominant Subgroups
ITYs M/RB	4431	55%	Paralithic Dystropepts Typic Dystropepts
ITYs S/RB	4432	10%	Paralithic Dystropepts Typic Dystropepts
ITYf S/T	4430	10%	Lithic Dystropepts Typic Dystropepts
ITUs M/LSS	4325	25%	Paralithic Ustropepts Typic Ustropepts

The first two soil map units differ only in the height of hill crests above the valleys. The second and third differ in kind of bedrock. The fourth soil map unit is in dryer areas and has limey bedrock. In all cases, the shallow and deeper soils are closely intermingled. All of the first three soil map units are entirely in RPU #2. The fourth is divided between this RPU and RPU #27.

Five soil subgroups are important constituents of this RPU. The approximate proportion of these and other soils is as follows:

Paralithic Dystropepts	35%
Typic Dystropepts	15%
Paralithic Ustropepts	15%
Typic Ustropepts	5%
Lithic Dystropepts	5%
Areas of rock outcrops, very shallow soils, and very steep slopes	10%
Deep alluvial and colluvial soils on less than 15 percent slopes	5%
Other soils, similar to Typic Dystropepts in agricultural potential	10%

The Paralithic Dystropepts are mostly on slopes steeper than 30 percent and have bedrock at depths less than 20 inches. The bedrock, mostly partially weathered acid igneous or metamorphic rock, is a barrier to root growth but in most places it can be excavated without blasting. These soils are low in base saturation and strongly acid. Most are stony and have clay loam texture nearly uniform with depth. They are well drained and have moderately slow permeability and very low available water capacity. They are not subject to flooding. Use of these soils is strongly limited by slope, depth to bedrock, stones, and acidity.

The Typic Dystropepts have slopes from 15 to 30 percent and steeper and depth to bedrock greater than 20 inches, ranging up to 60 inches or more. Because of greater depth they have higher available water capacity. Otherwise, they are like the Paralithic Dystropepts. Use of these soils is limited by slopes, stones, and acidity.

The Lithic Dystropepts are over hard tuff bedrock. Otherwise they are like the Paralithic Dystropepts. Use of these soils is strongly limited by slope, depth to bedrock, stones, and acidity.

The Paralithic Ustropepts are mostly on slopes steeper than 30 percent and have limestone or other limey bedrock at depths less than 20 inches. The rock is a barrier to root growth but in most places it can

be excavated without blasting. These soils are high in base saturation (many have free carbonates) and are moderately alkaline. Most are somewhat excessively drained, stony, and have clay loam texture nearly uniform with depth. They have moderately slow permeability and very low available water capacity. They are not subject to flooding. Use of these soils is strongly limited by slope, depth to bedrock, and stones. They are in areas with a dry season that limits cropping possibilities.

The Typic Ustropepts have slopes from 15 to 30 percent and steeper and depth to bedrock greater than 20 inches, ranging to 60 inches or more. Because of greater depth to bedrock they have higher available water capacity. Otherwise, they are like the Typic Ustropepts. Use of these soils is limited primarily by slope and limited soil moisture during the dry season.

RPU #2

Soil Properties and Special Features		Soil Map Units							
		ITYs M/RB (4431)		ITYs S/RB (4432)		ITYf S/T (4430)		ITUs M/LSS (4325)	
		Subgroups		Subgroups		Subgroups		Subgroups	
		Paralithic Dystropepts	Typic Dystropepts	Paralithic Dystropepts	Typic Dystropepts	Lithic Dystropepts	Typic Dystropepts	Paralithic Ustropepts	Typic Ustropepts
Composition of Components	%	50	30	50	30	50	25	50	20
Slope	%	>30	15-30	>30	15-30	>30	8-30	>30	15-30
Depth to Bedrock	m	0.1-0.5	0.5-2	0.2-0.5	0.5-2	0.2-0.5	0.5-2	0.2-0.5	0.5-2
Soil Texture		mod. fine	mod. fine	mod. fine	mod. fine	mod. fine	mod. fine	mod. fine	mod. fine
Coarse Fragments		stony	stony	stony	stony	stony	stony	stony	stony
Permeability		mod. slow	mod. slow	mod. slow	mod. slow	mod. slow	mod. slow	mod. slow	mod. slow
Reaction		strongly acid	strongly acid	strongly acid	strongly acid	strongly acid	strongly acid	mod. alkaline	mod. alkaline
Salinity		nonsaline	nonsaline	nonsaline	nonsaline	nonsaline	nonsaline	nonsaline	nonsaline
Available Water Capacity		very low	low	very low	low	very low	low	very low	low
Flooding		none	none	none	none	none	none	none	none
Soil Drainage Class		well drained	well drained	well drained	well drained	well drained	well drained	somewhat excessively drained	well drained
Base Saturation		<50%	<50%	<50%	<50%	<50%	<50%	calcareous	calcareous
Mean Annual Precipitation	mm	1800-2500		1800-2400		2000-2300		900-1300	
Mean Annual Temperature	c	20-25		25-27		24-26		20-25	
Local Relief	m	300-800		200-300		50-300		300-600	
Elevation	m	300-3000		100-600		100-700		200-1200	
Parent Material		metamorphic & igneous rocks		metamorphic & igneous rocks		volcanic tuff		limestone	
Distribution of Soil Map Unit	%	57		10		10		23	

152

RPU #10

RPU #10 is composed of flat, lowland estuarys and tidal flats with highly saline soils. The RPU is approximately 33,800 hectares in extent and occurs in three separate areas; two at and near the estuary of the Yuna River in Samana Bay and one at the mouth of the Yaque del Norte River in the northwest part of the country. The climate is wet with annual rainfall averaging 2,000 to 2,200 millimeters with a mild first-quarter dry season. The mean annual temperature is 25 to 27°C and nearly uniform throughout the year.

The native vegetation is mangrove along the coast with herbaceous perennials such as sawgrass, low woody plants, and some trees farther inland. None of the indigenous plants have any significant value and the area would be very difficult to convert to any kind of agriculture. Rainfall is sufficient for many crops but excessive for some and the dry season is too mild for others. The difficulty of drainage, salinity and problems caused by drainage make the RPU's agricultural potential very low.

This RPU consists of one map unit; identified by the map symbol HHTa WS/A and code 3111 in Appendix 1. Two soil subgroups are dominant in this RPU. They are not intermingled. The Typic Sulfihemists are in the wetter areas of greatest tidal activity while the Typic Tropohemists are found further removed from marine influence. The approximate proportion of these and related soils is as follows:

Typic Tropohemists	60%
Typic Sulfihemists	20%
Wet mineral soils	20%

The Typic Tropohemists are organic soils. They are very poorly drained, deep, level, slightly acid, nonstony soils. They have rapid permeability and high available water capacity. They are at tidal level or very slightly higher and suffer tidal flooding or flooding by streams. Most are slightly saline. Use of these soils is limited by wetness. Their position at sea level makes artificial drainage very difficult. If drained, these soils are subject to subsidence due to oxidation of the organic materials.

The Typic Sulfihemists are organic soils containing sulfides which convert to acid sulfates if the soils are drained. They are very poorly drained, deep, level, slightly acid, nonstony soils. They have rapid permeability and high available water capacity. They are flooded frequently by tides and strongly saline. If drained, these soils become extremely acid reaching pH values of 3.0 or lower. Use of these soils is very strongly limited by wetness and the impossibility of effective reclamation.

RPU #10

Soil Properties and Special Features		Soil Map Unit	
		HHTa WS/A (4219)	
		Subgroups	
		Typic Tropohemists	Typic Sulfihemists
Composition of Components	%	60	20
Slope	%	0-3	0-3
Depth to Bedrock	m	>10	>10
Soil Texture		organic	organic
Coarse Fragments		nonstony	nonstony
Permeability		rapid	rapid
Reaction		slightly acid	slightly acid
Salinity		strongly saline	strongly saline
Available Water Capacity		high	high
Flooding		frequent	frequent
Soil Drainage Class		very poorly drained	very poorly drained
Base Saturation		--	--
Other Features			becomes extremely acid if oxidated to convert sulfides to acid sulfates
Mean Annual Precipitation	mm	2000-2200	
Mean Annual Temperature	c	25-27	
Local Relief	m	1	
Elevation	m	tidal	
Parent Material		estuarian deposits	

RPU #17

RPU #17 is an area in the east-central Cibao Valley around Moca which consists of level terraces, foot slopes, and pediments over water-deposited sediments. The RPU contains about 100,000 hectares and is one of the most fertile areas in the country. The climate is moist with mean annual rainfall ranging from 900 to 1,500 millimeters with a distinct first-quarter dry season. Mean annual temperature is 25 to 27°C and is nearly uniform throughout the year.

The native vegetation appears to have been both savannah and subtropical broadleaf forest types. Essentially all has been cleared away and the area is intensively farmed. The climate is adequate for rainfed crops though some irrigation is practised with increased yields. The flat terrain with gentle slopes and favorable soils make the RPU extremely productive and well suited for agricultural production. Cacao, coffee, plantain and a variety of food crops are grown.

The RPU consists of one soil map unit, identified by the map symbol VUPg T/A and coded 6137 in Appendix 1. All of this map unit is included in RPU 17.

One soil subgroup is dominant. The approximate proportion of these and other soils is as follows:

Udic Pellusterts	70%
Wet, gravelly, steep, or frequently flooded soils	10%
Other soils, like dominant soils in agricultural potential	20%

The Udic Pellusterts are clayey, well drained, level, deep, nonstony soils not subject to flooding. The clay shrinks and swells with changes in moisture content and the soils crack deeply during dry periods. These soils are mildly alkaline and have high base saturation, slow permeability, and high available water capacity. These soils are well suited for agriculture. They have slight limitations due to the clay texture.

RPU #17

Soil Properties and Special Features		Soil Map Unit: VUPg T/A (6137) Subgroup Udic Pellusterts
Composition of Components	%	70
Slope	%	0-3
Depth to Bedrock	m	>5
Soil Texture		fine
Coarse Fragments		nonstony
Permeability		slow
Reaction		mildly alkaline
Salinity		nonsaline
Available Water Capacity		high
Flooding		none
Soil Drainage Class		well drained
Base Saturation	%	>50
Mean Annual Precipitation	mm	900-1500
Mean Annual Temperature	c	25-27
Local Relief	m	15
Elevation	m	50-300
Parent Material		stream & fan alluvium