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Final Report

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Introduction

This represents the final report of the Cornell University component of The Panama Agricultural Technology Development Project. This project was a joint participation effort by Rutgers and Cornell Universities in support of the Instituto de Investigacion Agropecuaria de Panama (IDIAP) under a contract with the United States Agency for International Development Contract No. 525-0180-C-00-2015-00.

Under terms of the subcontract, Cornell Univeristy provided one staff member, a soil productivity specialist, who participated as a line member of IDIAP for 24 months. This specialist was located in Santiago in the Central Region of Panama.

The responsibilities of the soil productivity specialist as determined in the contract, were as follows:

1. Participate in interdisciplinary applied research efforts to determine the most effective uses of natural resources (climate, land and soil, vegetation), and in the general areas of soil management and soil improvement for better production efficiency.
2. Concentrating in the priority areas, work on soil fertility evaluation, improvement, and maintenance programs, to help remove

one of the major factors limiting crop production in Panama. This would include studing fertility requirements for a wide variety of soils, (since requirements differ greatly depending upon their capacity to fix phosphorus), needs over time, various micro-element deficiency and other factors.

3. Help plan and implement specific on-farm investigation studies for enhancing soil productivity and for the investigation of proper soil management into land-use and productive livestock/cropping systems consistent with farm size and recommended farming practices.
4. Help identify and solve institutional, and policy factors (legal social, economic, manpower, credit, educational, etc) which influence efficient soil management and soil conservation practices.
5. Identify and recommend appropriate university study programs for IDIAP participants, for short and long-term academic training.
6. Assist in in-service training for IDIAP staff as well as production agents and farm leaders in soil management practices.

This final report by the soil productivity specialist consists of three parts;

I. Activities conducted by the specialist.

II. An overall assessment of the project in terms of the stated objectives.

III. Recommendations.

I. Activities

A. Benchmark Soils Project. Shortly after the soil productivity specialist arrived in Panama, he initiated a benchmark soils study to provide basic information about the most representative agricultural soils of the country. This involved identification of 17 representative sites throughout the country. Wherever possible, sites were selected on or adjacent to agricultural experiment stations in order to facilitate agrotechnology transfer. Soil pits were dug at the sites and detailed sampling was conducted by a representative of the Soil Management Support Service (SMSS) of the United States Department of Agriculture. Representatives of Cornell and Rutgers Universities, IDIAP, Ministerio de Desarrollo Agropecuario (MIDA), and Recursos Naturales Renovables (RENARE) observed and/or participated in the sampling and tentative soil classification of the various sites. Soil samples from all horizons at each site were sent to the USDA, Soil Conservation Service's (SCS) laboratory at Lincoln, NE for chemical and physical analyses. These analyses formed the basis for a tentative classification according to Soil Taxonomy.

The results of this effort including site location, have been completed and included in a draft manuscript (written in English) which has been prepared and is attached as an Appendix of this report, "Soil and environmental conditions of IDIAP agricultural research stations in Panama" by S. Jaramillo, L. Manrique, R. Bryant, T. Scott, B. Name and J. Jones.

IDIAP and SMSS plan to organize a two week regional training forum on the benchmark soils project in September or October 1985. In cooperation with IDIAP, SMSS will review the soils data at the various sites with soils specialists from Panama and the Central American Countries. The site selection, sampling, results of analyses and climatic data will be discussed. At that time, a final soil classification will be determined. Panamanian scientists will present data on crop response to fertilizer and soil management appropriate to the benchmark soils. The results of this forum will then be published in Spanish and English with Panamanian soil specialists as senior authors.

B. Soil Fertility Evaluation. The specialist spent time at the soil testing laboratory at Divisa. Analytical equipment was old and often inoperable. Advice was given on how to best work with existing

equipment and new procedures for analysis were offered to the laboratory director. The specialist assisted in setting up equipment for soil water determination and instructing the laboratory technicians on the use of the equipment. This was done in cooperation with Dr. Victor Snyder, a soil physicist from Cornell University.

The soil specialist assisted with the operations of the soil testing laboratory during the absence of the Panamanián director when he attended a six week short course in Vienna, Austria. During this time the specialist made fertility recommendations based on soil tests for all crops in Panama. The specialist also prepared a bulletin for fertilizer and lime recommendations based on soil tests. This included tables for fertilizer recommendations of all major food crops in Panama. This manuscript for the bulletin has been modified and translated into Spanish by the IDIAP staff. The bulletin is to be published soon.

Soil Fertility Field experiments were designed and conducted in cooperation with IDIAP staff and other members of the Rutgers/Cornell "team". The specialist helped design and conduct six field trials on subsistence farms in the vicinity of Sona. The purpose of this study was to develop a low technology input program for very low income

subsistence farmers on hilly farms not accesible by motor vehicles. This was done in cooperation with IDIAP scientists and MIDA extension personnel. This multiple cropping experiment consisted of four treatments: (1) the farmers current practice; (2) doubling the populations of upland rice; (3) doubling the population of rice using fertilizer and chemical weed control; and (4) doubling the population of an improved upland rice variety and the application of fertilizers and herbicides. This program is being continued and expanded in the Sona region.

The soil specialist assisted an IDIAP rice breeder in conducting a fertility experiment wiht rice varieties at the El Coco experimental station. Continuation of these studies will provide important management data for use on these kinds of soils. A benchmark soil site is on the same field.

The soil specialist designed a phosphorus experiment on beans for the general agronomy specialist. Recognizing the phosphate fixing ability of volcanic ash soils high in allophane such as those in the vicinity of Cerro Punta, the experiment was designed to test the hypothesis that these soils would respond only to unusually high levels of added phosphate fertilizer. Previous work in Costa Rica

suggested that rates of 100 kg ha^{-1} of phosphorus or more might be needed to achieve a response to phosphorus by Phaseolus.

Two cassava experiments were planted in May 1984. The objectives of these experiments were to study growth and yield performance of local cassava germplasm grown in a strongly acid Ultisol with and without applications of soil amendments. A set of soil, weather and crop parameters were recorded during the growing season. These studies provided basic information for crop growth analysis. Phenological events, leaf area development, dry matter production and dry matter allocation were monitored on a regular basis. Soil sampling at different time intervals and chemical analysis of soil samples were made to provide information on the efficiency of the use of liming materials in soils subjected to high rainfall intensity. The experiments are to be harvested by mid February 1985.

A long term phosphorus experiment on a highly phosphorus deficient Ultisol of Santiago was established in July 1984. The objective of this experiment was to monitor the effect of applying initial high levels of phosphorus on crop performance of a sequence of crops with differing phosphorus requirements. Rates of 0, 25, 50, 100 and 200 kg of

phosphorus ha^{-1} were applied on plots 6 by 4.5 m in July 1984. Beans (Phaseolus vulgaris L.) were planted in August 1984 and harvested at the end of November 1984. The data from this experiment has been provided to IDIAP.

In cooperation with the team member specializing in pastures, an experiment with pasture grasses and legumes was established in a Typic Plinthudult at Calabacito. The objective of this experiment was to study the response of Andropogon nad Stylosanthes in single and mixed stands, to increasing levels of nitrogen, phosphorus and potassium. After one year of estalishment, forage yield was evaluated in May, August, Ocotober and December. A joint journal paper on this experiment is planned.

C. Weather Gathering and Analysis. Three small weather stations were installed at sites located on Ultisols of Ocu, Santiago and Calabacito. Rainfall, air temperature, solar radiation, relative humidity and soil temperature are being recorded on a daily basis. The objectives are to provide local scientists with weather data that will help them to incorporate the effects of the environment when evaluating data. It is expected that IDIAP will continue with

the weather data gathering after 1984.

A systematic climatic data analysis at the National level was initiated in June 1984 to assess the impact of weather on crop performance at most IDAP experiment stations. Simple SAS computing programs were prepared to calculate potential evapotranspiration, dependable rainfall, moisture availability index and available energy (thermal units and temperature function units). A data base management program was prepared to handle, organize and retrieve climatic data and assessment outputs. These programs and climatic data collected from meteorological stations near experiment stations have been presented to IDIAP.

A long-term soil temperature experiment was established in a Ultisol at Santiago in January 1984. The objective of this experiment was to study the effect of different soil depths on temperature during the dry and rainy seasons. Soils of the Central Coastal Plain of Panama have an isohyperthermic temperature regime, however, the soil temperature data indicate that there is enough of a distinction in soil temperature between the dry and rainy seasons to contribute to yield variations of local crops. Soil temperatures were being measured at three depths, twice a month,

every two hours for a period of 18 hours. The experiment was terminated in December 1984. This data has been provided to IDIAP

Three experiments, two on cassava and one on beans, which were described early in this report, were established to gather soils, crop and weather data for crop modeling purposes. This effort was part of a joint cooperation between IDIAP and the International Benchmark Sites Network for Agrotechnology Transfer (IBSNAT) to establish the minimum set of data required to generate or test crop models.

D. Interaction with Visiting Scientists. The soil productivity specialist took advantage of opportunities to meet with various visiting scientists. However, comments will be made only on those scientists who served as consultants from Cornell.

Dr. Ray Bryant, Assistant Professor at Cornell University specializing in soil genesis and classification visited IDIAP twice for consultancies. Each visit was for two weeks. Dr. Bryant first visited Panama to assist with the sampling of the benchmark soil sites. After completion of the soil analysis in Lincoln, NE, he returned to Panama to discuss results of the soil analysis and the

soil classification based on the soil analyses with Panamanian soil scientists. During this time preparation of the manuscript for the benchmark soils bulleting was initiated.

Dr. Armand Van Wambeke, Professor of Soil Science at Cornell University visited the project for about one week. The purpose was to evaluate the progress of the soil productivity specialist and the interaction of the specialist with IDIAP's programs.

Dr. Victor Snyder, Assistant Professor of Soil Physics, visited IDIAP to assist in the development of a soil-water research program in Panama. Special attention was given to the Central region of Panama.

Trip reports of Cornell consultants are included in the appendix.

In addition, representatives of SMSS visited Panama and made tentative arrangements for a regional training forum utilizing the benchmark soil sites. The soil productivity specialist assisted in the review of most benchmark sites and developing a tentative schedule for the forum.

E. <u>In-service training</u>. Most activities considered as in-service training were on an informal or ad hoc basis. The specialist

presented a seminar to MIDA and IDIAP staff on Soil Taxonomy. In cooperation with Ing. Santander Jaramillo, a field trip was conducted on methodology of soil profile descriptions.

Dr. Victor Snyder, Assistant Professor of Soil Physics at Cornell University, conducted both a seminar and field trip on soil water management.

. Assessment of the Project in Terms of the Stated Objectives.

A. Introduction. Yields of food crops in Panama are low. Low productivity levels among small and medium size farmers are of special concern because of their large numbers of people and economic importance to the Government of Panama. Applied agricultural research information of high quality is needed to help alleviate this situation. Although a young organization, IDIAP is striving to accumulate information that will help the agricultural sector.

IDIAP operates under tight budgets and a shortage of adequate facilities and equipment. Research is organized according to specific crops or livestock, and a coordinated soils research program at the National level has been difficult to implement.

Soils research is conducted by only a few individuals in several parts of the country.

Production of food crops in Panama strongly depends on the rainfall distribution pattern. The main crops grown during the rainy season are rice, maize, sorghum, cassava and yams. The cultivated area (1976-1977) and yield of the main food crops were as follows:

Crop		Area	Yield
		has	10^3 kg ha^{-1}
Rice	mechanized	50,040	1.9
	nonmechanized	72,490	0.7
Maize	mechanized	5,540	1.3
	nonmechanized	77,610	0.7
Sorghum	mechanized	7,911	2.2

Source: Morales, C. and J. Schwartz. 1983. La mecanizacion agricola en Panama. Serie Estudios Especiales No. 2. Instituto de Investigaciones Agropecuarias de Panama.

Upland rice is grown from May through August although two crops of rice are obtained in areas where irrigation facilities are available. The specialist is aware of only one farmer producing rice under flooded conditions.

The soils of Panama are located in a wide range of ecological zones arranged in a narrow latitude belt. As a result of the interaction between the environment and their distinctive parent materials, soils of Panama have a wide range of soil properties. Food crops grown on these soils respond quite differently to soil management.

Nitrogen availability is the main constraint in most Mollisols, Inceptisols and Alfisols. Phsphorus is also deficient in many of these soils. Soil acidity and phosphorus availability are the two most limiting factors in Ultisols and acid ultic subgroups of some Inceptisols and Alfisols. Ultisols of Panama with a udic moisture regime have undergone intensive leaching and mineral weathering and have lost most of their capacity to retain nutrients. Crops respond to liming in these soils but the residual effect is short.

B. <u>Assessment</u>. Although some information exists about soil fertility and the management of Panamanian soils, there is very little

published information which could provide help and provide continuity to the soils portions of research and extension. It is important that investigators who do the research get their work into print. The lack of published materials contributes to the low visibility of IDIAP personnel.

Recognizing that it takes about a year to become familiar with the local personnel and knowledgeable about the agricultural situation, the soils specialist is satisfied that the soils portion of the project has been successful in achieving its objectives in the two year period.

A National soils committee was organized within IDIAP to provide more direction in coordinating soils work.

The benchmark soils project represented the major effort of the soils specialist. This project will provide a basis for continuing work and will facilitate interdisciplinary studies. It will also aid in the transfer of agricultural information within the country, the Central American region and other parts of the world. Scientists at IDIAP will have the base from which to extrapolate information from experimental stations to the same or similar soils within the country. The project also gives IDIAP scientists a leadership role in

soils within the country as well as visibility in the region. The collection and summarization of weather data will contribute significantly to the data base on soil-crop research.

Soil fertility studies were conducted in the field but were limited in scope because they had to be carried out only during the rainy season. Numerous trips were made with personnel from Transferencia (IDIAP) to visit farms, especially those near Sona. Most of these visits were in conjunction with the research project on the subsistence farms in the hills near Sona. This project is also being continued.

The only objective in the original scope of work that was not addressed was the one dealing with short and long-term academic training. The soil specialist was not asked to participate in this phase of the work.

C. Publications.

1. S. Jaramillo, L. Manrique, R. Bryant, T. Scott, B. Name, and J. Jonas. "Soil and environmental conditions of IDIAP agricultural research stations in Panama". Manuscript prepared and to be made available as an Agronomy Mimeo.

2. Luis A. Manrique. "A review of crop requirements for potato proudction with emphasis in tropical and subtropical regions' Manuscript prepared and soon to be published in the International Agriculture Series at Cornell University.

3. "Fertilizer and Lime Recommendations for Panama. manuscript prepared and soon to be published by IDIAP

III. Recommendations.

The following recommendations are presented but not necessarily listed in order of importance.

A. Soil Testing.

Efforts must continue to upgrade the quality of the service at the soil testing laboratory at Divisa. The physical structure is in bad condition. Much of the equipment is old and beyond repair. The morale of the technicians is low because of the condition of most of the equipment. Arrangements should be made for analysis of plant materials. There is not an operational Kjeldahl unit for nitrogen analysis. The quality control of samples being processed needs to be improved. The soils specialist recommends that a soil testing consultant be brought to Divisa for a period of one to three months to help improve the overall operations of the laboratory.

B. Soil Testing and Field Soil Fertility Studies

There is a need for research information to be generated that would correlate soil test values with crop response in the field. Critical soil test levels need to be established for the major crops. It is also recommended that fertilizer and lime recommendations based on soil tests, be made at the sub-regional level. Sub-regional specialists are more familiar with local conditions and in a better position to make valid recommendations. Soil tests can serve as an effective tool for other extension type activities.

For local specialists to be qualified to make lime and fertilizer recommendations, a series of training sessions should be held on a regional level.

C. Increase the research effort in the Central region of Panama.

Phosphorus availability and soil acidity are the two most limiting factors for food production in this region. The soil specialist must concentrate on establishing long-term field experiments that would increase crop production in the presence of the constraints. Specifically, the research should:

1. Identify plant species and genotypes which are efficient in utilizing nutrients from soils high in aluminum saturation (>60%), and low in phosphorus. The ultimate goal is to have a pool of cultivars capable of growing successfully on soils where applications of soil amendments are not feasible.
2. Develop methods to improve the efficiency of modest applications of soil amendments. A low technology input program would determine amounts and methods of placement of soil amendments for optimum plant growth and yield. These soils, for example, have a high capacity to fix applied phosphorus.

D. Research on Aluminum Toxicity and Efficient Use of Fertilizer Phosphorus

These studies should be concentrated on experiment stations near benchmark soil sites. This would provide accessibility, continuity and close monitoring of the experiments. This presents the opportunity for long term evaluations of phosphorus residual effects on crop response. The Calabacito Experimental Station would be a logical place to conduct such studies. The soil is an

Ultisol with high aluminum and low phosphorus. It is respresentative of the agricultural soils of the Central region and many other parts of Panama. It is reasonably close to IDIAP headquarters in Santiago and experiments can be easily managed.

E. <u>Establishment of a Data Bank for Soil, Crops and Weather Data</u>

It is recommended that IDIAP continue with the climatic data analysis at the National Level. Efforts should be made to establish small weather stations at most experiment stations to provide reliable data for the data bank. The purpose of the data bank would be:

1. To establish crop requirements (soil chemical, physical and environmental data) for the major food crops.
2. To develop a system to assess the capabilities of major agricultural soils for food crop production.
3. To ascertain the management inputs and agronomic practices required to achieve certain levels of crop yields at different management levels.

4. To determine the economics of various management strategies to achieve improved crop yields; both on a short-term and long-term basis.

F. Soil Resources Inventory.

The development of a soil resource inventory is crucial to the future of agricultural development in Panama. A review of soil survey work conducted in different areas of the country reveals only a limited number of studies that have been completed. There is a lack of uniformity in the methodology used for soil mapping and classification. This work needs to be updated using Soil Taxonomy as a basis for soil survey and classification.

Acknowledgement

The specialist in soil productivity gratefully acknowledges the assistance and support given by many members of IDIAP. He is especially appreciative of cooperation given by the Central region staff.

Appendix:

I. Soil and environmental conditions of IDIAP agricultural research stations in Panama, by S. Jaramillo, L.A. Manrique, R.B. Bryant, T.W. Scott, B. Name and J. Jonas

II. A Review of Crop Requirments for Potato Production with Special Emphasis on Tropical nad Subtropical Regions by Luis A. Manrique.

III. Recommendations de Fertilizante y Cal para la Produccion de Cosechas.

IV. Trip Reports